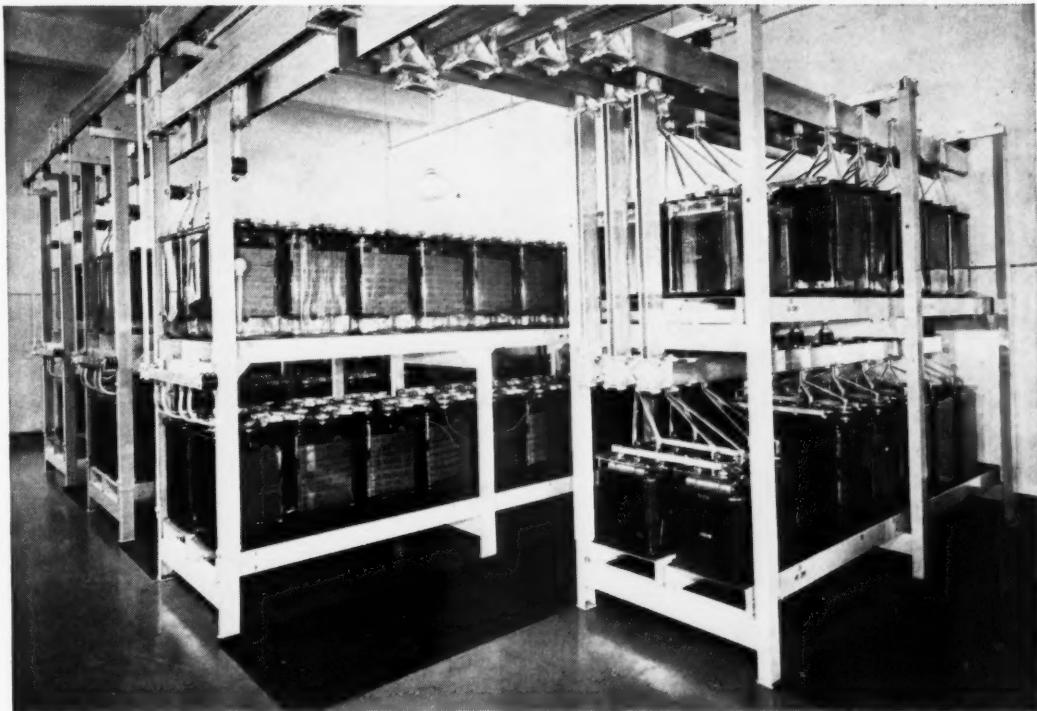


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Polarographic Studies of Storage Battery Acid

By A. C. WALKER
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AN IMPORTANT source of lead storage battery deterioration is the continual internal drain which results from self-discharge and sulfation caused by the presence of small amounts of metals other than lead. Two of these substances, iron and antimony, cannot be completely excluded in commercial battery manufacture. They may be present either as ions in solution or as adsorbed and deposited material on the active surfaces of the plates. The amounts of these impurities in solution are so small that it is difficult to follow their concentration changes during battery operation without taking unduly large samples for purposes of analysis.

In 1925, Heyrovsky and his co-workers in

Prague devised an electrochemical method of detecting extremely small quantities of substances in solution. This "polarographic" method is of value in chemical analysis and has been used in the Laboratories to measure quantitatively the iron, antimony and lead that is present in storage battery electrolyte.

The polarograph records on a chart the potentials at which substances in solution plate out on small drops of mercury as these form at the outlet tip of a capillary tube which dips into the solution. These drops of mercury are made the cathode of an electrolytic cell, and a pool of mercury at the bottom of the flask, which holds the solution, is the anode. A motor-driven potenti-

ometer raises the potential between the drop and pool of mercury continuously from zero to values high enough to plate out measurable amounts of all of the substances in the solution one after another. Meanwhile the recorder, which is synchronized with the potentiometer, plots a curve to show how the current through the cell varies with the potential applied to it. Very little current flows until this potential reaches a value characteristic of one of the substances in the solution. Then it increases suddenly and produces a step in the current-potential curve. These steps identify the elements present. The polarographic method of analysis is so sensitive that some substances can be detected in a million times its weight of water and the characteristic curves can be drawn in a few minutes.

A schematic of the polarograph, Figure 1, shows a solution *B* under test in a flask between a pool of mercury *A* and the dropping mercury electrode *c*. The battery *K* ap-

plies voltage to the solution through the slidewire potentiometer *E* which is motor driven at *M* to increase this voltage continuously. A galvanometer *G* measures the current through the solution and its deflections are recorded photographically on a chart *J* which rotates in synchronism with the drum of the potentiometer. A rheostat *N* controls the voltage applied to the potentiometer and a shunt *H* adjusts the sensitivity of the galvanometer for solutions of widely different concentrations. As the drop of mercury increases in size to about 0.5 mm in diameter and falls to the pool of mercury below, the reading of the galvanometer increases and then decreases. These swings would produce a jagged record if they were not practically eliminated by a heavily damped galvanometer. The electrolytic cell, Figure 2, holds from one to two milliliters of solution. Hydrogen is bubbled through it to remove oxygen which would affect the potential measurements. The

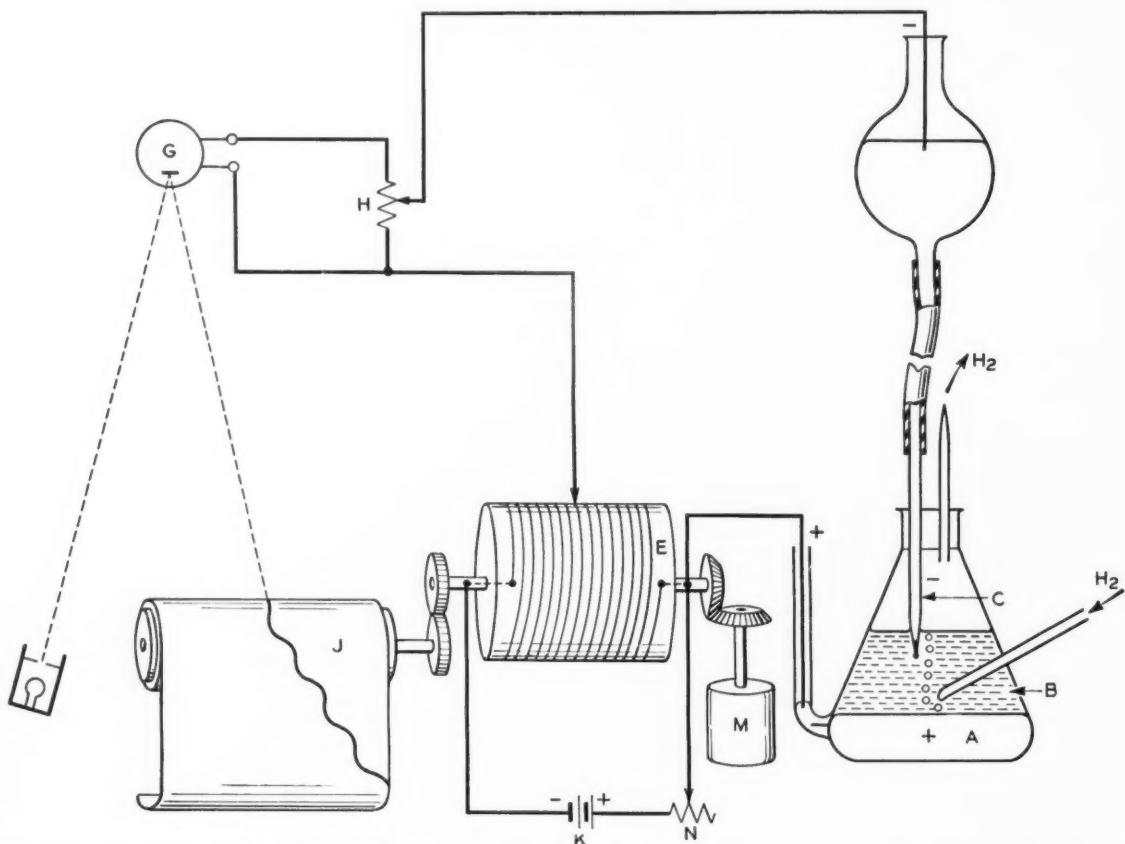


Fig. 1—Schematic of the polarograph. It determines quantitatively extremely small amounts of substances in solution by measuring the potential at which they are deposited electrochemically on a dropping mercury electrode

hydrogen inlet is just at the surface of the mercury pool, thus acting as a seal when the flow of gas is stopped and the test run is made. Prior to taking measurements, about five minutes suffice to remove the oxygen and adjust the potentiometer.

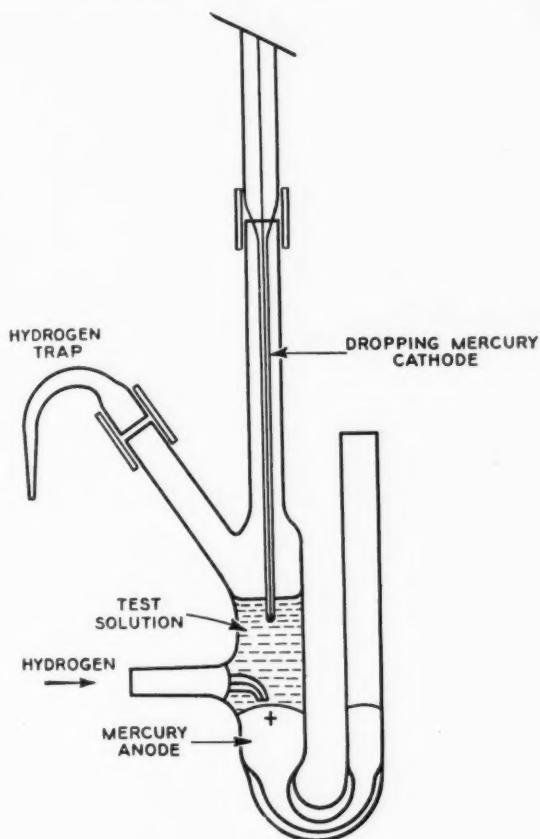


Fig. 2—The drop of mercury in a polarographic cell falls at approximately three-second intervals to the pool of mercury below. Hydrogen gas flows through the cell to remove oxygen which would affect the potential measurements

When potential is applied to two inert electrodes in a conducting solution, positively charged ions move toward the cathode and those negatively charged toward the anode. On arrival, discharge takes place, current flows, and substances may plate out on the electrodes or liberate gases there as a result of secondary reactions. These reaction products accumulate in the vicinity of the electrodes, decrease the flow of current and change the potential, a process called polarization. With the dropping mercury electrode this accumulation does not take place because the reaction

products are carried away with each drop when it falls to redissolve in the solution at the surface of the pool. Thus no change in concentration of the solution results from the electrolytic action in the polarographic cell. Polarization, as usually understood, does not take place, but another form occurs which is important to the success of the polarographic method, and from which it gets its name.

When the impressed voltage exceeds that required for the deposit of ions of a particular substance on the cathode, there is a sharp rise in current. The high current density on the small mercury drops makes all of

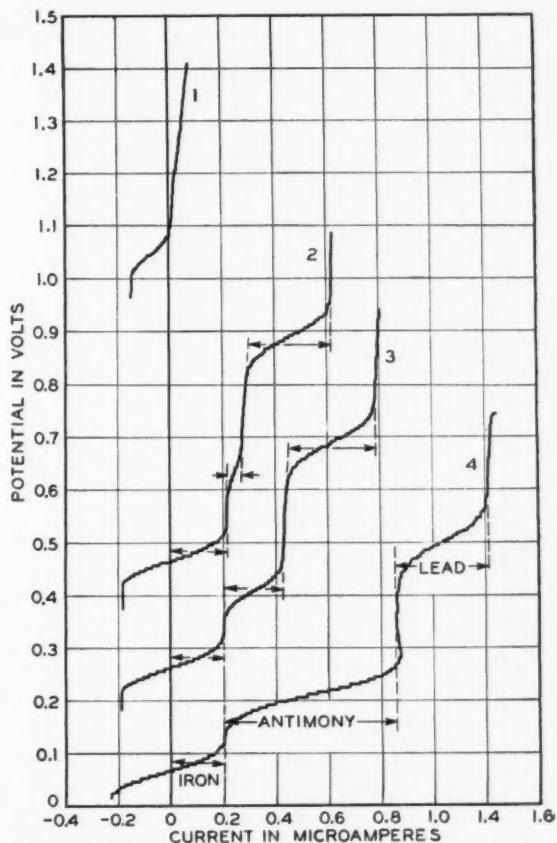


Fig. 3—Changes in current through the cell, as the potential applied to the electrodes increases, are recorded automatically. When a substance begins to deposit on the dropping electrode, the accompanying increase in current through the cell makes a step in the polarogram. The potential at which this occurs identifies the substance. Polarograms for different concentrations of antimony in the presence of constant amounts of iron and lead are shown in this figure

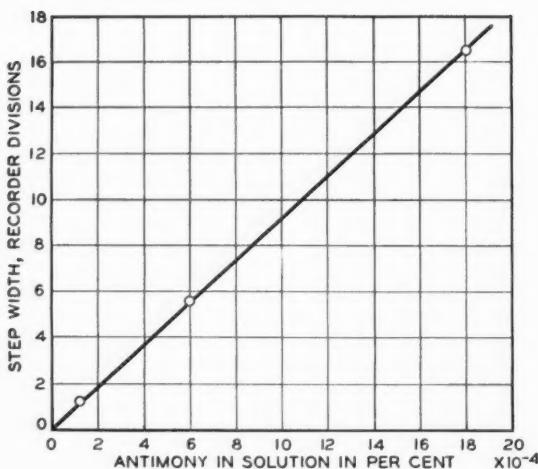


Fig. 4—Graph showing the relation between step width of the polarogram and the concentration of antimony in the solution

the ions of the reacting substance in the layer of solution at the surface of the drop tend to deposit at once, thus leaving this layer substantially empty with respect to these ions. Current flow is not reduced with time as it would normally be by polarization but it is limited to a constant average value, which is the rate at which ions of the substance depositing can diffuse from the main body of the solution into the surface layer surrounding the drop. This accounts for the step-wise character of the curve, and identifies this type of polarization.

If there are positive ions of more than one substance in the solution, that with the lowest electrode potential relative to mercury plates out first and produces the first step on the chart, Figure 3. Others follow in the order of their electrode potentials and each makes a separate step provided these potentials differ by 0.2 volt or more. The width of these steps (called wave-heights on the Heyrovsky form of chart) depends on the concentration of the metals in solution, the rate at which the reacting substance diffuses into the region immediately around the mercury and the rate of drop formation. Calibration of the apparatus with solutions of known concentration, while other factors remain constant, provides the information for determining quantitatively the composition of unknown solutions.

A step reaches its maximum width when the electrode potential suffices to electrolyze

all of the ions which diffuse through the solution to the surface of the mercury drop. The potential of the mid-point of the step is characteristic of the reacting substance and its value is not affected by changes in concentration. In practice, a supporting electrolyte, which deposits at a higher potential than the other constituents, is added to carry most of the current and reduce the resistance of the solution, thereby concentrating the fall of potential at the dropping electrode. In these studies ammonium chloride was used.

Iron is usually the most common impurity in storage batteries. By its dissolving in the electrolyte, ions are produced which oxidize at the positive and reduce at the negative plate, thus causing discharge and sulfation. This dissolved iron is adsorbed on the positive plates in appreciable amount and adsorption increases as the cell discharges. There appears to be an equilibrium relation between solution concentration and the amount adsorbed.

Antimony is alloyed with lead in the grids of storage battery plates to the extent of 5 to 15 per cent. It is leached out by the acid and deposited electrolytically on the active material of the negative plates during the charging cycle. In this state it is an important cause of self-discharge and sulfation.

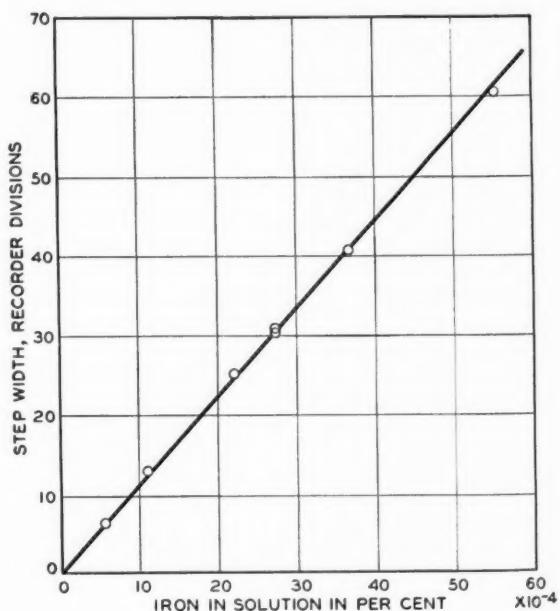


Fig. 5—Concentration of iron in solution in terms of the width of the polarogram steps

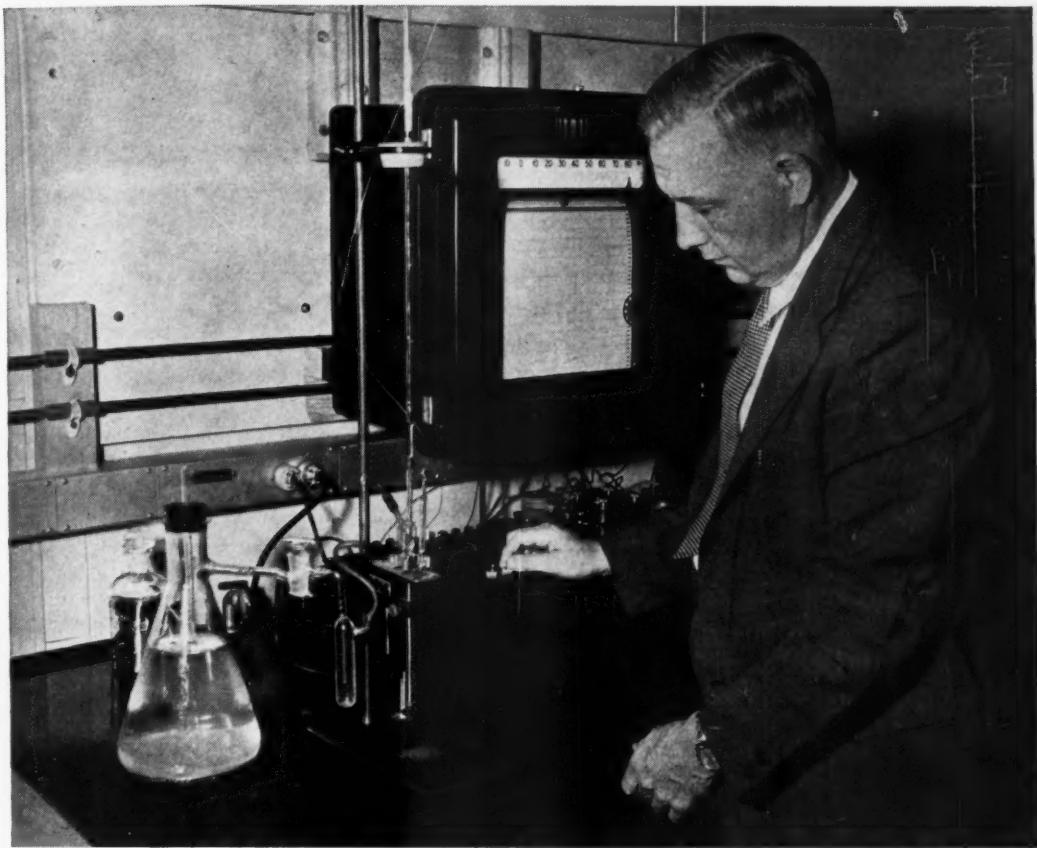


Fig. 6—The author employs the polarographic method to measure quantitatively the iron, antimony and lead present in a storage battery electrolyte

The amount in the electrolyte at any time is so infinitesimal that previous investigators have been unable to find measurable amounts, but there is no doubt that this electrolysis of antimony takes place. The supply in the grid is ample, the speed of solution and electrolysis is rapid, and considerable amounts may be transported to the negative plates even though there is very little in the solution at any time.

From solubility data it might be concluded that there is likely to be more than enough lead dissolved in the battery electrolyte to give significant polarographic waves. Actually there are rarely more than a few micrograms per milliliter although a discharged storage battery has somewhat more lead in solution than one which is well charged. Divalent lead may be determined quantitatively in the presence of iron and antimony in battery acid with the polarograph and all three of these metals can be evaluated with about the same precision.

Calibration curves for antimony in the presence of constant amounts of iron and lead and at concentrations which would be found in storage batteries are shown in Figure 3. The curves start at zero applied potential, but in strong ammonium chloride solution the dropping electrode acquires a small positive potential with respect to the pool of mercury when no external voltage is applied in the closed electrical circuit. To measure the deposition potential of these substances a small voltage has to be applied to reduce the current through the solution to zero. Thus only that portion of the first steps in each of the curves of Figure 3 to the right of the current axis are significant in this discussion and for convenience, current flowing toward the dropping electrode is designated as positive by making the dropping electrode more electronegative. Curve 1 of Figure 3 was made with a blank solution of three-normal ammonium chloride. There are no breaks in it beyond the zero line which

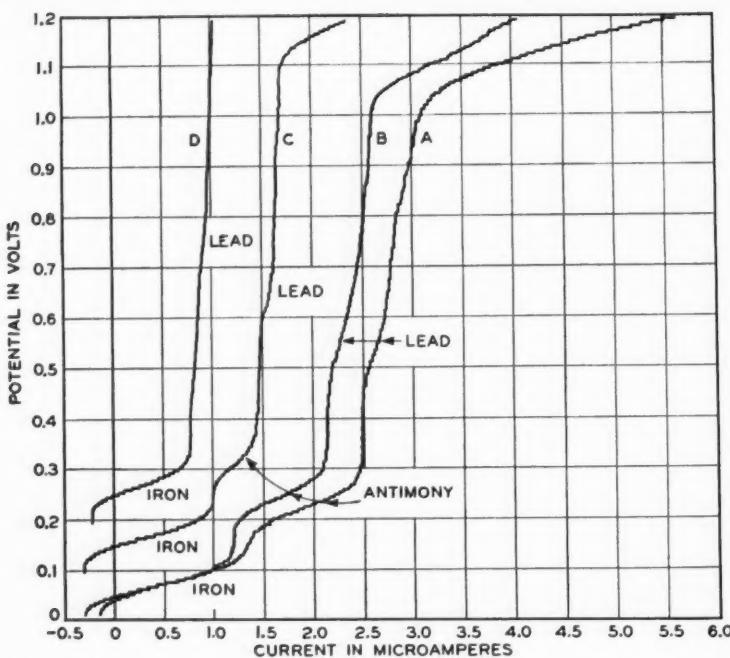


Fig. 7—Polarograms showing iron, antimony and lead content of the electrolyte of a commercial storage battery when discharged (A, B) and charged (C, D). Samples A and C were taken above the plates and B and D between them

shows that no metallic ions were present. The slight slope of this part of the curve is due to the ohmic resistance of the circuit.

Curves 2, 3 and 4 show how the width of the steps increases with increasing concentration of antimony in the presence of 0.1 milliliters of 0.001 molar solutions of iron and lead. The results are plotted polarographically in Figure 4, which shows a linear relation between step width and the antimony content of the solution. Iron analyses have to be carried out promptly after removing oxygen from the solution to avoid reduction of ferric to ferrous iron at the surface of the anode pool. The relation between iron concentration and step width is shown graphically in Figure 5. The data

antimony in solution when fully charged. After discharge this may increase to 0.0025 per cent. Acid from a dead automobile battery over four years old contained nearly 0.01 per cent of antimony. There was little difference in iron concentration in samples taken between and above the plates. The lead content of the electrolyte is surprisingly low, 0.0015 per cent.

These studies demonstrated that the polarograph is a valuable adjunct to life and capacity investigations on lead storage batteries. It can detect a few micrograms of iron, antimony and lead in their electrolyte, and quantitative determinations of these can be made in each other's presence with from 1 to 2 milliliters of solution.

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chemist for a paper mill and a firearms plant. Problems concerned with textile and paper research have occupied his time here, particularly methods of purifying and inspecting textile insulation. He is now spending his entire time on war work. Dr. Walker is a member of the Research Council and Board of Directors of the Textile Research Institute and also a member of its applied Research Committee.

are good to about 10 per cent at these extreme dilutions.

Representative polarograms obtained from the electrolyte of a commercial storage battery are shown in Figure 7. Curves A and B were made when the battery was completely discharged and C and D after charging twenty-four hours. Samples A and C were taken above the plates and B and D between them. Two divisions of the chart represent a microampere.

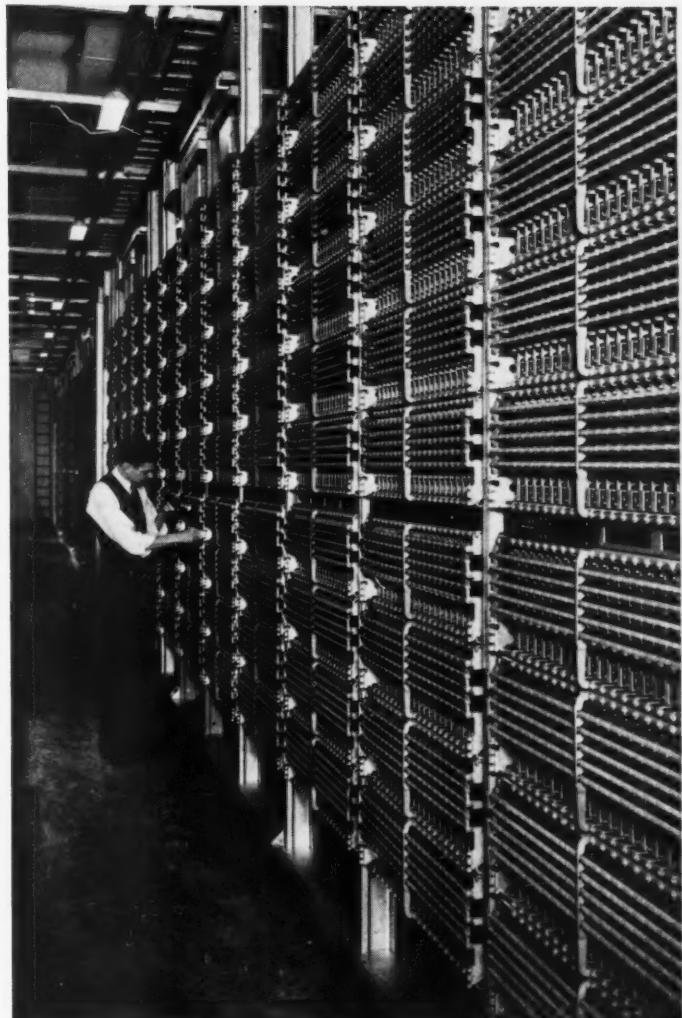
These and many similar polarograms showed that both old and new batteries contain about 0.005 per cent of iron in the electrolyte. The amount is somewhat higher in a discharged battery and is from two to three times that found in the long-life, stand-by batteries used in telephone offices. Both types contain from 0.0003 to 0.0015 per cent of

Crossbar Toll Switching System

By F. F. SHIPLEY
Switching Engineering

IN CROSSBAR switching systems, a train of two groups of switching frames is employed to interconnect incoming and outgoing lines of various sorts. Omitting all control equipment, the general arrangement is as indicated in Figure 1, where the term "lines" is used in its broadest sense to include subscriber lines, trunks to other central offices, or toll lines. In a local central office there are two trains like Figure 1. For one of them the incoming lines are from subscribers' stations, and the outgoing lines are trunks to other offices, or to other switching groups. For the other train, the incoming lines are trunks from other offices, and the outgoing lines are to subscribers' telephones. Interoffice trunks are connected to office-link frames for the outgoing train and to incoming-link frames for the incoming train and thus never appear on both ends of the same train.

A crossbar toll switching office differs in general features from a local office in that only one train is required, and in that no direct subscriber lines are involved at all. Both incoming and outgoing lines are toll lines or trunks to other offices, and since they may be either one-way or two-way, some will appear at only one end of the train, and some will appear at both. A call, for example, may come in to the crossbar toll office over a trunk from a local office for completion over a toll line to a distant center. The local trunk must thus appear on an incoming-link frame, and the toll line on an outgoing frame. If the toll line is a two-way trunk, however, it may handle a call in the opposite direction, and thus it will have to



appear also on the incoming frames. The terms "incoming" and "outgoing," therefore, do not necessarily refer to entirely different sets of trunks but rather to the direction in which the call is proceeding.

Another complication of the crossbar toll office is in the wide variety of trunks that must necessarily be accommodated. There is a broad division between manual and dial trunks, but the manual may be operated either as straight-forward* trunks or as ring-down trunks, while dial trunks may be designed for dial pulsing, d-c key pulsing, or multi-frequency key pulsing, or at the distant end they may appear at operators' positions equipped for either call-indicator† or call-announcer‡ operation. All these types of trunks require different treatment

*RECORD, April, 1929, p. 323. †RECORD, July, 1930, p. 515. ‡RECORD, January, 1930, p. 210.

whether they are of the incoming type or of the outgoing type or both.

All outgoing calls from the local area reach the crossbar toll office either from an outward position of a toll board or from a DSA board. If the outgoing line desired is of the manual type, the outward or DSA operator will key or dial a code to cause the crossbar toll equipment to select a trunk of

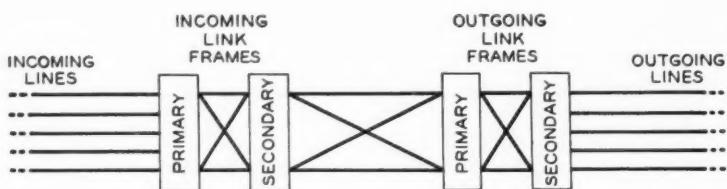


Fig. 1—A crossbar switching train consists of two frames with their connecting links

the desired group, and she will then pass the number desired to the distant operator. If the call is to a dial trunk, the operator dials both a code to select an idle trunk of the group desired and also the number of the line wanted at the distant end.

Incoming calls may be either for completion in the local area or for switching to some distant city, and either type may arrive or require completion over a manual or dial trunk. If the call arrives over a dial trunk for completion in Philadelphia, the distant operator will dial both the office code—which will guide the crossbar toll equipment in selecting a trunk to the proper office—and the subscriber's number, which will select the proper line in that office. If a call arrived over a dial trunk but were for an outgoing toll line, the operator would dial a code to guide the crossbar toll equipment in selecting the proper trunk, and would then either dial the distant number wanted if the trunk selected were of the dial type, or would repeat the number to the distant operator if it were of the manual type.

If the incoming call were of the manual type, on the other hand, regardless of whether it were for a local or through connection, it would be connected to a cordless position forming a part of the crossbar toll office. An operator here would receive the order from the distant office and write it up on strip keys—the entire number if the call

were to be completed by dial, but only a three-digit code to select a trunk if it were to be completed manually.

For every call passing through the crossbar toll office, an incoming sender is connected to the calling line to assist in establishing the connection. This sender associates itself with a marker to which it passes the three-digit code to guide the selection of an idle trunk and the establishment of a connection through the incoming and outgoing frames. If the call is to be completed over a manual ring-down trunk, the sender disconnects itself after the connection has been established through the crossbar toll office, and the operator at the distant end of the incoming trunk handles the call from then on. If the

call is to be completed over an outgoing toll line equipped for multi-frequency pulsing, the incoming sender, after the connection through the crossbar toll office is established, will send the proper pulses over the toll line to complete the connection at the distant end.

Had the call required completion over an outgoing dial toll line other than of the multi-frequency type, an outgoing sender would have been connected to the outgoing trunk when it was seized by the marker, and as soon as the connection had been established through the office, the incoming sender would have transferred to it the digits to control the connection at the distant end. The incoming sender would then have disconnected itself, and the outgoing sender would complete the work at the crossbar toll office.

A block schematic for the crossbar toll office is shown in Figure 2. Senders of all types are connected to the trunks through sender-link frames, which are under the direction of controllers. With incoming dial trunks, a sender-link frame connects a sender directly to the trunk, but with manual trunks, an operator-link frame connects the trunk to a cordless position with each of which a sender is directly associated. All the incoming senders have access to markers through connectors, and transmit to them the three-digit code that designates

the group of outgoing trunks desired. As determined by the particular code, the markers operate a trunk block relay to reach the group of trunks desired, and test them for busy. Having selected an idle trunk, the marker establishes a connection to it and then disconnects itself.

After the marker has established a connection through the train, the incoming sender acts in one of three ways, depending on the type of outgoing trunk. With a manual ring-down trunk, it disconnects itself and allows the operator at the calling end of the trunk to pass the needed information over the trunk. With a trunk arranged for a-c key-pulsing signals, it transmits the required pulses over the line in accordance with the number it has recorded. With other dial trunks, it passes the number desired at the distant end to an outgoing sender which had connected itself to the trunk through a sender-link frame when the trunk was seized. The incoming sender will then disconnect itself, and the outgoing sender will transmit the required pulses over the line. Outgoing senders are also employed when call-announcer or call-indicator pulses are to be sent over the trunk.

As already pointed out,* one of the ad-

*RECORD, November, 1933, p. 101.

vantages of the new switching system is its ability to connect repeaters into the circuit when required. These, also, are connected to the trunk through link-frames as indicated on the diagram, and like the outgoing senders, they are connected automatically as required.

A feature of the crossbar toll office is the use of four-wire switching throughout. The crossbar switches of the incoming and outgoing-link frames connect four wires for the talking circuit instead of two as do the equivalent local frames, and the switchboard positions used for handling delayed calls use four-wire plugs and jacks.

One of the major advantages of the new system is the increased speed with which calls are handled. This may be illustrated by considering the time involved in placing dial calls through the office. As soon as a trunk to the crossbar toll office is seized, a sender-link frame connects a sender to the trunk. The time required for this operation is less than one second, and as soon as the sender is connected, it transmits a signal to the calling end to indicate that dialing may begin. The operator then starts dialing or key-pulsing the number. There will be three digits to select a group of trunks located in the crossbar toll office, perhaps from

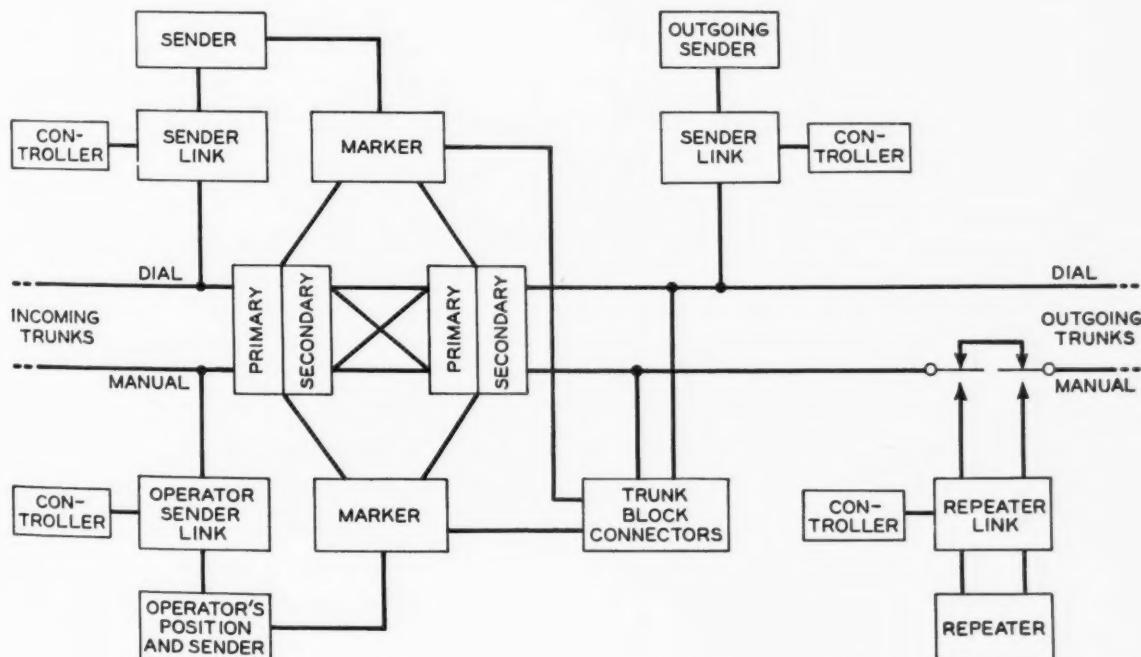


Fig. 2—Block schematic showing the main circuit components of the crossbar toll system

one to three digits to guide switching at an intermediate office, and from four to eight to select the office and subscriber in the city called. These pulses are sent at a rate of about one digit per second if they are from a dial, or at a rate of two digits per second if they are being sent by key-pulsing from the outward toll office in the local area, and as soon as the incoming sender has recorded the first three, it seizes a marker, and transmits the three digits to it simultaneously. The marker then operates the block relay for the required group of trunks, selects an idle trunk, and makes it busy to other markers. It then finds an idle path through the switching train to connect the incoming and outgoing trunks, and closes the circuit through. This has required about one second, and after the crossbar switches have operated, the marker disconnects itself to be ready to handle another call.

When the outgoing trunk was first selected and made busy by the marker, it was automatically connected to an outgoing sender through a sender-link frame. This sender is connected at about the time the marker establishes the connection through the switching train, which—as already indicated—is about one second after the three-digit code is recorded by the incoming sender. During this interval the incoming sender has been recording the remaining digits, and has not yet finished. It at once starts transmitting them to the outgoing sender at the rate of ten digits per second

by d-c key pulsing, and as soon as the outgoing sender receives them, it relays them over the line to drive the switches at the distant end of the line. As soon as all digits have been recorded and relayed to the outgoing sender, the incoming sender disconnects itself, and the outgoing sender disconnects as soon as the last digit has been sent over the line. All common equipment used in establishing the connection has now been released, leaving only the connection to be used for conversation. With this overlapping operation the work at the crossbar toll office is completed in very little more time than is required to record the digits dialed.

THE AUTHOR: F. F. SHIPLEY received the B.S. in Electrical Engineering degree from Purdue University in 1925 and at once joined the Department of Development and Research of the American Telephone and Telegraph Company. Here he worked largely on general toll switching problems, but also devoted much time to certain patent studies. Transferring to the Laboratories in 1934, he continued work on toll switching problems—particularly those relating to mechanical methods that later resulted in the crossbar toll office.



Processing Quartz

By W. L. BOND

Chemical Laboratories

THE production of a small thin quartz plate from a large quartz crystal weighing several pounds involves a long succession of operations, including repeated cutting, surfacing, and checking. Each step requires some form of grinding or lapping, and with the extremely high precision required and material as hard as quartz, these processes are slow and exacting, although multiple processing—carrying through a number of crystals simultaneously—reduces the net time per crystal considerably. Until crystals began to be used extensively in electrical work, the grinding of hard brittle substances was limited chiefly to jewels, and the techniques and materials employed were not very well suited to large-scale processing of quartz. As a result, a considerable amount of research and development was carried on in these Laboratories to discover the most satisfactory methods and to design the most useful machines.

Hardness of brittle materials is usually determined by a scratch test, using the Moh scale of hardness. This scale evaluates hardness relative to the ten substances shown starred in Table I. Small fragments of these ten substances are commonly mounted on the ends of sticks, and the hardness of a sub-

stance is estimated by the ability of one or another of these standard substances to scratch it. Quartz ranks No. 7; harder substances are topaz, sapphire (corundum), carborundum, diamond and some of the very hard steels. The method of cutting such materials consists in continuously repeated scratching with large numbers of small fragments of some harder, or at least equally hard, substance. There are two ways in which this scratching may be accomplished: grinding and lapping.

No universal agreement exists as to the nature of the processes to which these two terms are applied. In our work here, however, the term grinding is applied when the scratching particles, usually called the abrasive, are bonded together, and thus held fixed, while the term lapping is applied when the abrasive is loose—ordinarily mixed with a small amount of water. One form of grinding medium is sand or emery paper, where the abrasive is glued to the paper. The more typical form is the grindstone or grinding wheel, usually of carborundum. With these, the abrasive is held together with a minimum amount of binder. This leaves a porous structure, and as the scratching points are broken or worn away, new points are exposed to carry on the work. It is necessary to remove the cutting debris as it is formed so that the interstices between the abrasive points do not become filled. With high-speed wheels, centrifugal force is ordinarily sufficient, but water is frequently used for this purpose, and has the added advantage of cooling the surface being ground, and thus avoiding overheating.

With the lapping process, some hard flat surface called the lap is covered with wet abrasive, and the surface to be lapped, called the work, is laid on top of the lap and moved back and forth or around to cause the abrasive to scratch the work. As already noted, the abrasive material must be hard,

TABLE I—MOH HARDNESS OF A NUMBER OF SUBSTANCES

*Talc	1	Glass	4½-6½
Lead	1½	*Apatite	5
*Rocksalt	2	*Feldspar	6
Copper	2½-3	Garnet	7
*Calcite	3	*Quartz	7
Brass	3-4	Steel	5½-8½
Dolomite	3½-4	*Topaz	8
*Fluorite	4	*Corundum	9
Phosphor Bronze	4	Carborundum	9½
Iron	4-5	*Diamond	10

but it must be tough also, or it will break too easily, and not properly perform its function. During the lapping process, the abrasive acts on the lap as well as on the work, and thus the material of the lap has considerable effect on the rate of cutting. Studies were therefore made to determine the relative merit of various substances when used as the lap in lapping quartz. One study determined the cutting speed for various

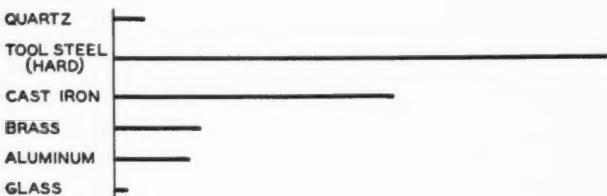


Fig. 1—Relative resistance to abrasion of several commonly used lapping materials

laps and for two grain sizes of abrasive, and another determined the resistance to abrasion of various materials that might be used for laps. In this latter study the lap employed was of cast iron. The results of these investigations are shown graphically in Figures 1 and 2.

From Figure 1 it will be seen that the four metals have much greater resistance to abrasion than the quartz or glass, and that the resistance is in the same order as the hardness. The very soft aluminum, however, wore two and a half times as well as quartz, and yet on the Moh scale, aluminum ranks 2 while quartz ranks 7. This is explained by the toughness of aluminum and the brittleness of quartz. The abrasive particles bury themselves deeply in the aluminum without removing pieces of the surface, while the brittleness of quartz enables the abrasive particles to break off small pieces, and thus the wearing away is faster. Glass, which is softer than quartz and even more brittle, wears away still faster.

When used as the lap, however, glass proves very effective—ranking next to the hard tool steel, which was best. Glass is so hard that the abrasive cannot bury itself in it, and thus remains active. Although the glass will wear faster than the tool steel, it remains effective as a lap.

These studies also showed that the cut-

ting rate is roughly proportional to the size of the abrasive particles. No. 240 carborundum passes through a screen with 240 openings per square inch, while 600 passes through one with 600 openings. The 240 particle is thus 2.5 times the size of the 600. Comparing the results shown in Figure 2 reveals that the 240 particles cut just slightly under two and a half times as fast as the 600.

In passing between the work and the lap, the particles are broken up, and if the abrasive is fed in from the edges of the work, only smaller pieces reach the center, and thus cutting becomes slower. Another fact these tests brought out is that this situation can be improved by cutting grooves in the face of the lap to form a grid by which larger particles may reach the interior of the work. The gridded cast iron lap was as good as tool steel, while the smooth cast iron lap was little better than brass.

Since lapping speeds increase with the hardness of the abrasive, diamond abrasive is the most satisfactory. Diamond, however, costs about \$45,000 a pound while

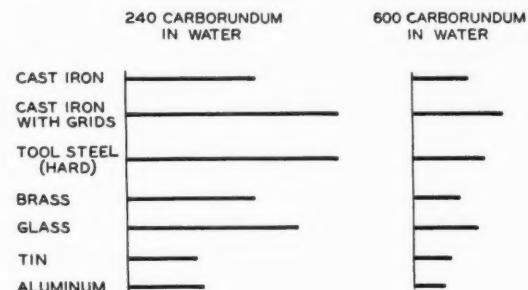


Fig. 2—Relative lapping speed of quartz with various materials for the lap

carborundum costs from 15 to 60 cents a pound. For loose lapping, therefore, where relatively large quantities of the abrasive are used, the use of diamond is prohibitive.

In lapping quartz, a gridded cast iron lap is used which revolves on a vertical shaft. The carborundum abrasive, in a soap-water solution, is painted on the work, and the speed of the lap is kept low enough so that the abrasive will not be thrown off by centrifugal action. For rough lapping, coarse abrasive is used, but as the work continues, the size of the abrasive is reduced to secure

a smooth surface on the finished work. In lapping sections and slabs,* the quartz is secured in a holder that is brought down against the lap by a lever. This holder itself is free to rotate and is controlled by an eccentric that moves the quartz in and out from the center of the lap as the lap revolves. The finished crystals are lapped by the "nest" method, using a machine developed in these Laboratories that will be described in a forthcoming issue. By various lapping procedures, the sections, slabs, and crystals are brought to the proper thickness and given parallel flat faces. Between these lapping steps, however, a large amount of cutting is desired, first to make the sections, then the slabs, and finally the crystals themselves.

Cutting has commonly been done by "muck sawing." A thin steel disc is used that rotates on a horizontal shaft and dips into a suspension of carborundum and soap-water. The quartz or other material is pressed against the edge of the disc, and cutting is done by what is essentially a lapping process. Because of the action of the abrasive in flowing over the sides of the cut, a V-shaped groove results which is wasteful of material, and makes it difficult to secure faces ground accurately to the desired angle.

This method was used for early work on quartz, but more recently a grinding process has been employed using a diamond saw. A steel or copper disc is "charged" with diamond abrasive by pressing the diamond particles into the softer metal. This becomes a grinding rather than a lapping process because the abrasive particles are held fast instead of being suspended in a liquid, and since the abrasive is held securely in the disc, higher rotation speed is possible, and faster cutting is secured. The higher speed requires a more rigid machine than does the slower muck sawing, and the disc must be accurately round and centered to prevent hammering. The saw is mounted on a movable arm, and is brought down on the quartz which is securely held beneath it. Since there is no fluid abrasive running over the sides of the cut, more nearly parallel sides are obtained than with the muck saw.

*RECORD, March, 1944, p. 320.



W. L. BOND, shown above, entered the Laboratories in the fall of 1928. In studies of the piezo-electric effect in minerals he has surveyed the whole mineral field and made similar investigations of many synthetic crystals. Mr. Bond has designed optical, X-ray and mechanical equipment for the orientation, cutting and processing of crystals. He also served as consultant on quartz crystals with the War Production Board. Mr. Bond received the B.S. in Physics in 1927 and the M.S. in 1928 at Washington State College.

These various lapping and grinding processes, while simple to describe, require precise manipulation and carefully designed apparatus to produce high quality work. The finished crystal must frequently be ground to within 12 millionths of an inch. A variation of this magnitude is so small that it cannot be measured with a micrometer caliper, and must be determined by the frequency at which the crystal oscillates. Only painstaking processing enables as high a precision as this to be attained.

Report of Employees' Benefit Committee

THE following is the report for 1943 of the operations performed under the "Plan for Employees' Pensions, Disability Benefits and Death Benefits" which is administered by the Employees' Benefit Committee under the chairmanship of R. L. Jones. The other members of the Committee are E. W. Adams, A. B. Clark, J. W. Farrell, W. Fondiller, M. J. Kelly, and G. B. Thomas. J. S. Edwards is Secretary of the Committee and K. M. Weeks, Assistant Secretary. The purpose of the Plan is to provide payment of definite amounts to employees when they are disabled by accident or sickness or when they are retired from service, or, in the event of death, to their qualified dependents.

At the close of the year there were outstanding 137 service pensions, 16 disability pensions, and 3 special pensions. During the year 29 members of the Laboratories withdrew from active service, 9 under the Retirement Age Rule, 11 because of disability, and 9 at their own request. This is an increase of 5 retirements over last year.

Seventeen active members of the Laboratories and 9 retired members, 3 of whom were retired because of disability, died during 1943. Death benefits were authorized in all instances where there were beneficiaries qualified under the Plan.

The decided upward trend in occurrence of accidents during the course of employment which has been so marked since 1940 continued in 1943. The number increased 84 per cent over the previous year although the average severity, as indicated by working days lost, decreased 27 per cent. The actual amount of payments of accident disability benefits and for medical and related expenses, though slightly less than that made in 1942, equals approximately the total payments during the period from 1938 to 1940, inclusive. However, when considered in proportion to payroll, these payments per \$1000 of the standard payroll show, in comparison to the payments made in 1942, a decrease of 25 per cent. ■

Statement of Benefit Payments for the Year 1943

Under the "Plan for Employees' Pensions, Disability Benefits and Death Benefits" the following benefit payments were made during the year 1943:

Payments by Trustee from Pension Trust Fund:

Service Pensions.....	\$250,391.25
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Payments by the Company:

Disability Pensions.....	7,651.62
Payments after Death of Pensioners.....	16,899.29
Accident Disability Bene- fits and Related Expenses	15,308.69
Sickness Disability Benefits	192,879.04
Sickness Death Benefits...	61,124.88

Total Benefit Payments . . .	\$544,254.77
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BELL TELEPHONE LABORATORIES, INC.

(Signed) A. O. JEHLE,
General Auditor.

February 4, 1944

In common with the experience in New York City and throughout the country, there was a rising sickness incidence evident during the year. Sickness disability benefits were paid to eligible employees for 869 absences of more than a week's duration, an increase of 12 per cent per 100 employees over the preceding year; working days lost per 100 employees remained approximately at the 1942 level. Absence due to sickness not under the Plan—payments charged to department expense for sickness absences of less than one week's duration, for the first-week absences of benefit cases, and for absence to those with insufficient service to be eligible to sickness benefits—totaled 248 cases per 100 employees for the year, an increase of 50 per cent over 1942, and involved payments amounting to \$366,712. Working days lost per 100 employees for

these cases increased 63 per cent over the preceding year. These facts indicate that the increase in sickness absence during 1943 was attributable to short-term sickness, the duration of which was greater than in the past but not great enough to reflect a significant increase in sickness under the Plan.

Supplementary payments in the form of Special Benefits and Supplementary and Special Pensions amounting to \$8,542 were paid to 26 active and 12 retired members of the Laboratories in need of special assistance during 1943.

As a result of the War, leave of absence activity has increased tremendously. At the beginning of 1943 there were 378 on leaves of absence, 284 of which were military leaves. During the year 628 leaves of all types were granted, 181 completed, and 825 members of the Laboratories were still absent at the close of the year. Those on leave consisted of 713 in the Armed Forces, 14 in the Merchant Marine, 32 engaged in war work in a civilian capacity with the Government and allied agencies, 13 for disability reasons, and 53 for personal reasons.

(Signed) J. S. EDWARDS, *Secretary
Employees' Benefit Committee.*

Vail Medals Awarded W. E. Men for Heroism at Time of Explosion

For acts of valor performed at the time of an explosion in the Western Electric Company's vacuum-tube shop at Hudson

Street, Vail Medals have been awarded to Louis G. DeLyon (posthumously), Alfred H. Gerlach, Alexander Mikolasy, William Mohrhoff and Louis J. Rom.

At fifteen minutes past midnight on the morning of November 30, 1943, an explosion rocked the vacuum-tube shop at Hudson Street. Heavy steel doors were ripped from their fastenings, walls were crushed while broken glass and debris littered the streets for blocks around. Gas leaking from hydrogen tanks had ignited and caused the disaster.

Mr. DeLyon, supervisor of the hydrogen equipment, with three fellow employees, Messrs. Gerlach, Mohrhoff and Rom, entered the gas room immediately upon learning of the initial trouble. Again and again the escaping gas drove them out but with full knowledge of the extreme hazard involved they persisted in an attempt to avert the tragedy. All were injured by the resulting explosion and Mr. DeLyon lost his life.

Mr. Mikolasy, hearing the blast and guessing its probable location, proceeded from the third floor of the building to the scene where he discovered a fellow employee whose clothing was on fire. After extinguishing the fire and removing the victim to safety with the help of a bystander, Mr. Mikolasy entered the gas room where a violent flame from the tanks threatened at any moment to touch off further disaster. In disregard for his own safety he persisted for

Lieut. M. M. Reiss, Officer in Charge of the students detailed to the Laboratories School for War Training under the sponsorship of the Aircraft Radio Maintenance Division, Wright Field. The students are trained by engineers of the Laboratories for maintenance work on Air Service Command and Air Forces Airborne Electronics Equipments. He is assisted by Doris Newman (left) and Blanche Sembroff (right)



more than fifteen minutes closing the operating and cylinder valves until the fire was extinguished. His unusual courage is credited with preventing further explosions.

Preparedness and Teamwork, 1944 Version

The recent total failure of one of the toll cables on the Cleveland-Toledo route and the full restoration of service within eighteen hours provided an example of the effectiveness of teamwork and long-range engineering.

At 12:20 p.m., February 9, a barge scraped the submarine section of the A-cable in the navigation channel of the Maumee River in Toledo. The nitrogen gas pressure inside the sheath failed to hold back the moisture, and the cable went out. With it went facilities for 480 type-K carrier circuits and approximately 250 voice-frequency circuits. It was one of the largest toll failures at one spot that had occurred in Bell System history.

To restore as many message channels as possible within a short time, maintenance forces first turned to rearranging the carrier apparatus for the undamaged companion B-cable, which normally handles carrier



BLOOD DONORS

H. W. Allison	Charles Kuhl
F. J. Bertola	A. N. Luce
Joseph Blank	R. MacMillan
J. R. C. Brown, Jr.	James Morrison
John Cebak	W. H. Nelson
H. L. Downing	Catherine Noto
William Guldner	Irene Ryan
A. A. Hansen	George Schenk
A. C. Holetz (7)	G. Seidel
Elizabeth Howard	J. M. Snyder
C. W. Koons	F. W. Stubner

Jean Van Dusen

messages in one direction only. This emergency procedure, which made it possible for messages to move temporarily in both directions over the same cable, restored 120 circuits within two and a half hours after the break.

Meanwhile, a third cable which had been in place as a stand-by for a number of years was cut over, and by 6 o'clock the next morning, the full number of circuits was back in operation.



F. R. Kappel, Operating Vice President of the Northwestern Bell Telephone Company, was a recent visitor at the laboratory buildings at Murray Hill. D. H. Wenny, Jr., is explaining to him uses made of one of the large rolling mills in the metallurgical laboratory

News Notes

WALTER S. GIFFORD's talk, *Private Enterprise and Freedom From Want*, presented before The Franklin Institute at the time he received the Vermilye Medal, was published in the January issue of the Institute's *Journal*.

R. L. JONES has been appointed chairman of the Post-War Planning Committee of the American Standards Association. Dr. Jones recently visited the new Western Electric plant at Haverhill, Mass.

W. A. SHEWHART has been elected President of the Institute of Mathematical Statistics for 1944.

AN ARTICLE BY S. A. SCHELKUNOFF, entitled *Representation of Impedance Functions in Terms of Resonant Frequencies*, appears in the February issue of the *Proceedings of the Institute of Radio Engineers*.

IN CINCINNATI, R. K. HONAMAN addressed a joint meeting of the Engineering Society and local sections of I.R.E. and A.I.E.E. on February 17. This was the first presentation of his subject, *War Developments of Bell Telephone Laboratories*, to the general public. The following day in Cleveland he repeated the talk to an invited group of Ohio Bell people. On both occasions Mr. Honaman showed the motion picture *Electrical Gun Director*, taken at Murray Hill last November by H. G. ARLT, J. H. WADDELL and H. J. SMITH. In addition

to that development he described the Spiral-4 System, the Alaska Highway telephone line, radio sets for tanks and planes, mass production of crystal, and other recent developments.

L. S. INSKIP recently attended the Regional Conferences on foreign wire relations, inductive coördination and transmission at Excelsior Springs, Mo., Berkeley, Calif., and Denver, Col. In Iowa City Mr. Inskip participated in an investigation of power and telephone plant by engineers of the Rural Electrification Administration and Northwestern Bell Telephone Company.

R. M. BURNS spoke at the February 17 joint meeting of the Western New York Section of the American Chemical Society and the Niagara Chapter of the Electrochemical Society. He is president of the latter organization.

The Applied Sciences of Nutrition, an article by R. R. WILLIAMS, was published in the January issue of the *Journal of The Franklin Institute*.

C. M. HILL spent a week at Hawthorne on synthetic rubber problems.

B. S. BIGGS, H. PETERS, G. N. VACCA and G. G. WINSPEAR attended the D-11 Committee meeting of the American Society of Testing Materials, held in Cincinnati in February. The D-11 Committee deals with rubber products.

March Service Anniversaries of Members of the Laboratories

10 Years

W. F. Arsmson
G. W. Eckner
J. V. Elliott
Aristede Pellegrinelli

15 Years

N. K. Balderston
Catherine Bennett
Ralph Biddulph
C. E. Brooks
N. W. Bryant
James Crabtree
H. M. Craig
V. W. Dobler
W. E. Dunham
R. D. Fracassi

D. M. Jones
E. M. Julich
W. C. Kleinfelder
M. J. Larsen
T. E. Lenigan
A. A. Lundstrom
L. De K. Mann
F. H. Martin
Frank McGlynn
Florence Michels
R. L. Miller
R. C. Miner
E. D. Morris
A. A. Roetken
Emily Roussel
Thomas Rushetski
G. H. Snyder
Ethel Stehle
P. G. Uppstrom

20 Years

Charles Depew
Ernesto Fontana
D. J. Hendrick
C. L. Karthaeser
Gladys Kettles
L. F. Koerner
C. W. Koons
S. O. Morgan
R. V. Rice
H. J. Smith
T. C. M. Woodbury

25 Years

C. P. Bertgis
P. W. Blye
Orfeo Cesareo

K. K. Darow
R. A. Horsburgh
P. F. Jones
R. A. Ogg
H. C. Rubly
M. K. Zinn

30 Years

L. E. Coon
T. L. Dowey
E. H. Goldsmith
Max Nowak
H. M. Stoller

35 Years

W. L. Casper
W. G. Knox



Around the World

With

Our Service Men

Lieut. Owen N. Giertsen

LIEUT. OWEN N. GIERTSEN, who was reported missing in action in New Britain, has been located. A telegram from the Government on February 21 contained this good news and the assurance that his family would hear from him soon.

Robert E. Henneberg

ROBERT E. HENNEBERG, whose Army assignment is guarding prisoners of war, had some interesting sidelights to offer on them.

"One out of every twenty Germans speaks English fluently," he says. "Either they have gone to college in England or they have lived in Chicago or New York for a time. Contrary to what most American soldiers believed, the Germans are religious and nearly every man carries a well-worn Bible in his possessions. They sing exceptionally well because one hour a day of basic training is devoted to singing. Regardless of their backgrounds, they enjoy working on farms and are particularly interested in cotton, which they had never seen growing before. A band of Germans who had been captured while guarding Americans who were prisoners in Africa, claim that our boys are equally as well cared for as they are in every way."

Charles J. Kuhn

"At present my outfit must start a Victory Garden. The jungle soil is very fertile and there's plenty of sunshine and rain here. I believe we will have vegetables growing in no time. The Japs had gardens on most of these islands. I ate many sweet potatoes that were planted by the enemy and I saw a Jap garden that had lettuce, radishes and other vegetables growing. I often wondered when

the U. S. would wake up to the fact in regard to planting these islands."

John E. Sienko

"I am temporarily in a Naval Hospital for repairs. Don't know when I will be put back into circulation. At this point I am not feeling so well, but I hope for a speedy recovery."

Capt. Einar Reinberg

"I have recently been transferred from Fort McClellan and am at present participating in maneuvers with the Yankee Division as a liaison officer. King Mud reigns in these hills where we awaken in the morning with the ground covered with frost. Then we plod our weary way through the daily thawing-out process which follows. Am growing restless after three and a half years of service and am hoping that these will be our final examinations. All of us are anxious to put some of this training into practice."

Leonard M. Nielsen

"I wish to thank all who sent Christmas cards to me. For a while I thought I was forgotten and then they came. It was a wonderful feeling just to open the envelopes and find that so many friends had remembered me. The scenery here in Greenland is beautiful. No matter in which direction a person turns he can see one mountain after another covered with snow and ice. Skiing is about the most popular sport among the men at this time of year."

John J. O'Shea

"For some time now I have been stationed in England and I like it here. It's rather quiet with the exception of an oc-

casional air raid; the blackout is strictly enforced. At times we find it difficult to get around, but that is a minor problem when one stops to think of what we've been through. I have been lucky all during these campaigns and I hope my luck holds until we march down the streets of Berlin. Then I will be contented."

John C. Ptacek

"I am now in California. I was transferred off the * * * a few days ago when she docked at Pearl Harbor. I came back on a transport and we are just getting squared away. Now at last I can tell you what I've been doing for the last six months while I've been out in the Pacific war zone. Right after my last letter we went down to the Solomon Islands and were in the battle of Kula Gulf with the Jap fleet or rather a part of it. We then came back to base about the end of July when I sent the gadgets home. After making repairs and taking on supplies we went on the Marcus Island raid which was only 500 miles from Tokyo itself. We got back to base a few weeks later and then went on the same kind of a raid to Tarawa Island to soften it up for the invasion. With very little damage to ourselves we again returned to base, and after getting supplies and resting up a few days we went to Wake Island. I guess you've read in the newspapers about the shellacking we gave the Japs there.

"I had quite a few personal experiences there myself. I was in the group of Marines who went to pick up survivors of our downed planes on the southern tip of the island. The Japs surprised us there though and we lost quite a few men, nearly including myself. Some Nip had the range on me and put two rifle slugs through my pack. As far as the operation went, though, it was quite a success as we rescued 17 officers and over 40 enlisted airmen. I was sure lucky to get back to the ship after crawling around the beach for about an hour. After we got back to base from Wake we went down and landed the troops on Bougainville in the Solomon Islands. We stayed down there about three weeks and then went up to Tarawa where the Marines landed. That was the bloodiest battle I ever saw and I never want to see one like it again. After

a week and a half at Tarawa we raided the Marshall Islands to the north and went back to base just before Christmas. Christmas Eve we left again for the southwest Pacific but we got torpedoed New Year's Eve so didn't get far and put back to base. Almost half the crew were killed. I'm not hurt or anything like that if you were wondering but can use a few months' rest. It's really God's country and the chow is swell. It's just what I prayed for so often when we were hammering it out with the Japs."

Raymond S. Yerden

"Since leaving California I have had a little trip and am beginning to believe that this is a big old world, and a tough old war. It is quite an interesting place that I am in. The climate is good and we are able to go swimming often."

Lieut. Paul Mallory

LIEUT. PAUL MALLORY's note to LEAH SMITH, thanking her for two books which he needed, was written within 400 yards of the front lines. "It is the first time I have had the experience of living close to the front and it is rather interesting. The worst thing we



JOHN C. PTACEK



W. B. BACHMANN



G. E. HELMKE



J. F. GULBIN

have to contend with is rain, every day and every night."

George E. Helmke

GEORGE E. HELMKE, formerly an instrument maker in the 4B Shop, returned in February to visit his friends in that section. Mr. Helmke had been aboard a destroyer, had seen action in Sicily and spent considerable time in the Mediterranean and at a base in Northern Ireland. In November he was relieved of sea duty and has since been on the staff of the Navy Direction Finder School in Maine.

Flight Officer John F. Gulbin

Before going to his new assignment at Bowman Field to receive his Infantry training, FLIGHT OFFICER JOHN F. GULBIN called on friends at West Street. He had recently been commissioned as a Glider Pilot. As such he will land groups of Infantry men on a strategic spot after the glider has been cut away from a plane at a scene of action. "Glider piloting isn't easy work," Mr. Gulbin says, and he compares it with driving a Mack truck.

Mildred F. Bourne

From Technical Assistant at Murray Hill to Athletic Instructor in the Marine Corps was the first hop of a flight made last September by MILDRED (Kiki) BOURNE. She is now teaching judo, a form of jujitsu, at the Marines' Air Station, Cherry Point.

Walter B. Bachmann

After a long assignment in the Alaskan area, WALTER B. BACHMANN of the Equip-

ment Development Department returned home on leave. Walter is the nephew of L. H. BACHMANN at Graybar. He had been at Dutch Harbor, Adak and Amchitka, as well as on the Aleutian invasions. The Japs hadn't a chance there, he thought, because what they built by night was bombed to bits by day. Among the things which they left behind were quantities of opium.

Leaves of Absence

There were 740 members of the Laboratories on military leaves of absence and 14 members on Merchant Marine leaves as of February 29, 1944.

Army 461	Waves 26	Wacs 11
Navy, Marines and Coast Guard 234		
Marine Corps Women's Reserve 6		
Coast Guard Reserve 1	Nurse Corps 1	
Merchant Marines 14		

Recent Leaves

United States Army

John H. Berntson	James J. Feeney
William P. Brander	Edward J. Schaum
John E. Cronin	Arthur F. Schweizer
William G. Dougherty	Alfred Wickstrom
Warren E. Wilson	

United States Navy

Charles F. Christoph	Ens. Austin R. Suneson
James P. Craven	Matthew Tomb
Howard J. Rohr	Lt. Charles H. Will

<i>U. S. Marine</i>	<i>Merchant Marine</i>
Lt. Arthur R. Parker, Jr.	Lt. Henry J. Bopp

Military News

RECENT PROMOTIONS among Laboratories members in service include: RODMAN DE KAY and NELS C. YOUNGSTROM to the rank of Commander; WARD K. ST. CLAIR to Lieut. Colonel; HAROLD B. GUERCI to Major; THEODORE N. POPE to Captain; WALTER B. BACHMANN to Petty Officer 3/c; JOSEPH A. CEONZO to SoM 2/c.

COMMANDER NELS C. YOUNGSTROM returned recently from the Mediterranean area to this country for a new assignment.

CAPT. THEODORE N. POPE was a visitor to the Laboratories in February. His assignment is Washington.

IN CHARLES R. STORIN'S V-mail to the RECORD, he writes that he's still in Italy and everything is just about the same. His turkey holiday dinners complete with trimmings were a welcome relief from the steady diet of stew and Spam.

LEON P. NEWBY has gone overseas and has a San Francisco Fleet P. O. address.

WILLIAM V. HOSHOWSKY, aviation cadet, is studying at Darr-Aero-Tech, Georgia.

HARRY B. COMPTON, now at Casco Bay, Maine, has been at sea, but he expects to have a leave shortly.

"I AM now with a mobile repair unit and reclamation squadron," THOMAS J. CALVANI writes. "From now on I shall be seeing quite a bit more of England."

ENSIGN EDWINA E. GOLDING is an assistant supply agent in the Purchase Division at the Boston Navy Yard.

JUNK JEWELRY OFFER

Members of the Laboratories in the Pacific theater of war are welcome to the large collection of junk jewelry which has been donated by the girls at West Street. In the past many instances have been cited where the natives have carried wounded from the front lines, dug fox-holes, and done similar work in order to secure jewelry with which they love to bedeck themselves. The cost of shipment will be borne by members of the Laboratories.

"I REALLY don't know what I'd do without the experience in electrical work I picked up at the Labs," LOUIS A. BERGDAHL writes from Texas A. and M. "It looks as if the Labs and the Navy are on the same team. You develop it—the Navy will keep it running."

ANNE L. KOS is a Mess Sergeant at Fort Oglethorpe where she is feeding the girls who are sent into the field. "The job isn't easy," she says, "but I love it."

AFTER LEAVING the Laboratories School for War Training, ENSIGN FRANK ZYLLA was assigned to the Naval Research Laboratory at Anacostia.

FROST G. HIGBIE of the Marines is studying * * * at New River.

PHILLIP E. WATTS visited the Apparatus Drafting Room in February.



Phillip P. Crowe, student pilot on leave from Maxwell Field, Alabama, seemed to be enjoying himself on a visit to the Bureau of Publication. With him: Charlotte Bortzfield, Mary Reddington, Thelma Daniels, Clare Lent, Helen Trezza, Hilda Muller and Ethel Bradley



LT. COL. A. M. ELLIOTT



W. L. WILLDIGG



JOHN SCHARF



F. W. GARLAND



ROBERT KLEM



A. M. BECKVAR

"I'VE BEEN doing a little flying but most of it is at night." WALTER A. FARNHAM writes, "The other night we headed out for Oregon on a cross-country hop and on the way back got lost; before we knew it we were around Los Angeles."

LIEUT. COL. A. M. ELLIOTT is stationed in Jacksonville, Florida; ROBERT KLEM, at Salina, Kansas, and A. M. BECKVAR, at Marfa, Texas. JOHN SCHARF had completed his course at the Laboratories War Training School about the time that FRANK W. GARLAND entered the School. W. L. WILLDIGG has gone overseas.

FROM ITALY, his first assignment after North Africa, JOHN J. LORDAN sends word that the leading articles in the December '43 RECORD give a complete picture of the work he is doing.

WILLIAM M. EHLER, who is a *** technician in the Marine Corps, was given a February furlough from Cherry Point, N. C., where he is waiting for a squadron.

"REGARDS to Whippany and the boys at BTLSFWT at Hudson Street," from ENSIGN

THOMAS M. BRAY who is at the Navy Overseas Base, Norfolk, Va.

"The Telephone Hour is on the radio now," RICHARD RAFFERTY writes, "and it makes me kind of homesick for the Labs."

MICHAEL SHEEHAN is with an Engineers Battalion at a New York overseas address.

FROM KEY WEST, Florida, where he is at the Naval Air Base, ALBERT J. LEIMER sends word that he would appreciate hearing from his friends.

LIEUT. COL. JAMES W. MCRAE of the Signal Corps is at Alexandria, Virginia; LIEUT. COL. ROBERT L. KAYLOR's APO number is in care of the Postmaster, San Francisco; while LIEUT. COL. WILLIAM J. GALBRAITH has a New York APO number.

Among the Laboratories men at the same APO number are ALFRED WICKSTROM and THOMAS J. CALVANI; FRANK R. MONFORTE and LIEUT. PAUL MALLERY; EDWARD L. FISCHER and ROBERT T. LYNCH.

ELENA R. TIGHE did not find Oklahoma all that she had expected of the wild and woolly West. Instead, Stillwater, a sleepy little college town, is the home of a Naval Training School at Oklahoma A. and M. Elena extends her kindest regards to all.

"I have been in the hospital for some time," RICHARD C. WILLIAMS says. "It will take a while longer before I get out and I'll be glad to return to active service."

CATHERINE M. COVERT of the Waves is stationed in Washington; HENRY J. BOYLE is somewhere in England; DANIEL J. BRADY's latest Army address is Northern Ireland; MAJOR THOMAS A. McCANN is overseas; LIEUT. B. B. CALDWELL is at Colorado Springs; ENSIGN RICHARD H. KOEHN is at Banana River Station, Florida.

JAMES W. ERICSSON sends greetings from England where he is enjoying himself.

GEORGE J. WOLTERS has a new APO number at San Francisco. It is the same as BURTON L. JAMISON'S.

"BEST REGARDS to all—especially the gang in 1725 at Whippany," from JOHN H. ROONEY, who is at Camp Polk.

WILLIAM J. CONNER is off on another exciting adventure as a beach jumper.

LAWRENCE M. CASSANO is at Camp Lejeune; ENSIGN GEORGE E. ORAM is at Harvard University. J. P. SLICKERS and W. R. CAROLAN are taking college training, the one at State Teachers College, Johnson City, Tennessee, the other at the University of Utah. CAPT. O. C. OLSEN is at Dayton, Ohio; GERARD E. DAVIS, at Victoria, Texas, flying P-40's.

MARGARET S. MACILVAINE has received a Pharmacist Mate's rating in the Waves and is serving in the Naval Hospital, Bainbridge, Md.

ON A FIFTEEN-day furlough from Camp Phillips, CHARLES W. MUCCIO was glad of a respite after desert maneuvers. Mr. Muccio was formerly editor of the *Bell Ringer*.

A FORMER RECEIVING Department man, SPENCER N. FOSTER, wrote as he was leaving the country: "I saw my name on a list to leave tomorrow for a cold country. However, anything can happen in the Navy. I was on a brand new can (destroyer) yesterday and boy was it a honey! Plenty of stinging power, too."

CATHERINE LENNON is stationed at Arlington, Virginia, where she is doing mathematical research work for the Signal Corps.

RUSSELL L. VALENTINE writes that, "Whenever a storm whips up, the ship

turns very acrobatic. She will lie on one side, a second later lie on the other side, raise her bow up out of the sea and then push it under the waves, ending up by going along so smoothly for a few seconds that you wonder if you had not drunk too much when you look back at your tracks."

ON THE EQUIPMENT with which JOSEPH A. CEONZO is working in St. Augustine he has frequently noticed that the schematics are from the Laboratories.

BECAUSE HE is in an anti-aircraft outfit overseas, JULIAN M. WIENER was particularly pleased with the extensive description in the RECORD of the Laboratories' new electrical director for AA fire.

"HI FOLKS! I'm near the end of my training when I hope I will get the Navy's wings of gold," DONALD W. MACK writes. "Regards to all my friends out at the Murray Hill laboratories."

JACK ROBACK studied Lab equipment at the School of Applied Tactics at Orlando. Now he is in San Diego, waiting for a chance to get overseas so that he can put his extensive training into practice.



L. M. CASSANO

CAPT. O. C. OLSEN



G. E. DAVIS

J. P. SLICKERS



ENS. G. E. ORAM

W. R. CAROLAN



Frank A. Koditek talks over the routines of his job with Eileen K. Dolan who is taking his place in the Quality Assurance Department

"I HAVE found a great amount of enjoyment in reading the many interesting articles in the RECORD," JOHN R. NELSON says in a note from his station at sea.

AFTER GRADUATING from the third term in basic engineering at Syracuse, ROBERT A. DRYDEN was sent to Camp Shelby where he is awaiting an assignment.

LIEUT. THOMAS J. DOHERTY is at San Francisco; R. S. WILLIAMS, at Camp Crowder; and T. E. BAILEY, at Bainbridge, Maryland.

LIEUT. MARGARET GRAY is on active duty at Pensacola, Florida. She was relieved of her desk job in Washington and is now doing engineering work on assemblies and repairs.

JOSEPH R. MAY and WALTER LICHTE have been in some of the same M9 director classes at Fort Eustis, Virginia.

AFTER SPENDING a month at Mechanicsburg, Pennsylvania, studying the routines and procedures involved in se-

curing and storing supplies, LIEUT. S. MILTON RAY has returned to Clearfield, Utah.

JOSEPH U. MEATS on his way over wrote to RAY GIBBY in the Receiving Department: "I am now on my way to the greatest adventure of my life. Am bunking with a full-blooded Apache Indian who speaks eight languages including Japanese."

WARREN M. PRALL is an aviation cadet at Corpus Christi, where he is undergoing the final stages of his training.

THE LETTERS which ROBERT S. WILLIAMS receives from Room 1217 at Varick Street and the RECORD help to keep him feeling he is a part of the Labs, he says.

The following members have also written to the RECORD:

F. R. Misiewicz, Harry Verges, E. J. Burns, J. R. Walsh, D. H. Wright, V. B. Obermiller, M. E. Poulsen, Alfred Bertin, G. E. Linehan, W. T. Reck, M. C. Ruggiero, R. J. Drout, H. E. Earl, A. A. Hauth, A. W. Schmidt, David Webster, W. F. Johnson, M. E. Johnson, P. P. Crowe, C. N. Peterson, R. J. Nielson, J. E. O'Keefe, R. B. Burns, Harold Jaffe, R. E. Komuves, D. F. O'Sullivan.

B. L. Jamison, T. E. Jew, E. J. Filipovits, R. R. Stephens, F. R. Hulley, A. J. Nolan, Capt. W. W. Maas, F. E. Schellhorn, F. C. Wanits, R. W. Search, Major A. L. Whitman, J. H. Anderson, R. C. Lamont, J. J. Rosato, T. R. Harden, H. H. Sharpe, W. F. Wilson, W. D. Elliott, W. Burkart, E. J. Buckley, H. H. Hoffman, Peter Yurica, M. L. Glaab, W. J. McKee, K. J. Osiecki, A. J. Osinski, H. G. Remels, J. H. Devereaux, G. E. Fuchs, R. J. Seymour, P. E. Watts.



LIEUT. T. J. DOHERTY

R. S. WILLIAMS

T. E. BAILEY

April 1944

News Notes

AT THE SYMPOSIUM ON *Industrial Applications of X-Ray Diffraction*, held in Brooklyn on February 26 by the American Physical Society, W. O. BAKER spoke on *X-Ray Diffraction in High Polymers*.

M. D. RIGTERINK visited Lenox Inc. at Trenton in connection with ceramic production problems.

C. J. CHRISTENSEN, M. D. RIGTERINK, W. F. JANSSEN and S. O. MORGAN conferred with engineers of the General Ceramics Company on ceramic problems.

A. N. HOLDEN, A. C. WALKER and C. J. CHRISTENSEN were in Hawthorne studying crystal growing problems.

SPECIAL INSULATION was discussed by D. A. MCLEAN at the Eastern Regional Research Laboratory in Philadelphia.

W. L. HAWKINS was chosen by the Board of Trustees of Howard University to receive its annual alumni award for distinguished post-graduate achievement in the field of chemical research. Dr. Hawkins was the guest of the University at its Charter Day dinner and delivered a short address in connection with the award. He has held Canadian and National Research Fellowships and is the author of numerous papers on organic chemistry. At present he is engaged in war work in the Chemical Laboratories at Murray Hill.

A PAPER, *Diffraction of Water Through Plastic Materials*, by G. DEEG, JR., and C. J. FROSCH, was presented by Mr. Frosch in Philadelphia at the A.S.T.M. Symposium on Plastics. Mr. Deeg also attended.

Engagements

*Paul Hopf—*Mary Bishop

Ira V. Hermanns—*Alice Croker

John Clancy, U. S. Navy—*Marie Fletcher

*Alexander E. Gerbore—*Margaret Portelroy

Weddings

Anthony Gaeta—*Annette Fazio

Commander H. Clark Corbin, U. S. M. S.—

*Dorothea Holshuh

James S. Tryon, II—*Joan Mason

William Marks—*Vita Padlog

*J. Jan Jansen—Martha Wilson

*Members of the Laboratories. Notices of engagements and weddings should be sent to Mrs. Helen McLoughlin, Women's Editor, Room 1103

R. G. McCURDY, A. B. HAINES and C. J. FROSCH were at the Sharon, Pa., plant of the Westinghouse Company on February 24 with members of the Western Electric Company to discuss and inspect processes for moisture proofing power transformers.

B. E. STEVENS was at Hawthorne and at the Jefferson Electric Company of Bellwood, Ill., from January 27 to February 3 to facilitate the production of power transformers. On his return, he also visited the Line Material Company of Zanesville, Ohio, to discuss similar problems.

AT THE Line Material Company of Zanesville, Ohio, J. B. DECASTE and R. W. DEMONTE investigated the wire which is being used in the manufacture of power transformers.

L. E. MILARTA with H. W. Toom of Point Breeze visited the Automatic Winding Company, Inc., of East Newark, N. J., on February 15 in connection with high-voltage transformer production.

E. B. WHEELER visited Hawthorne and the Underwriters' Laboratories in Chicago, February 14 to 16, on matters relating to special station apparatus for use in hazardous areas.

A. R. KEMP, F. S. MALM, G. N. VACCA and J. B. HOWARD discussed rubber-covered wire problems at Point Breeze.

G. H. WILLIAMS went to the Norton Co., Worcester, Mass., and to the Hercules Powder Co. and the E. I. duPont de Nemours Co. at Wilmington, Del., in connection with adhesives.

C. J. FROSCH visited the Westinghouse plant at Sharon, Pa., to discuss the treatment of power transformers. He also visited the Reynolds Spring Co. at Cambridge, Ohio, to investigate molded plastic domes. He has recently been appointed temporary chairman of the Society of Plastic Engineers.



DENNY

You can make your copy of the RECORD available to a serviceman's family after you have read it by dropping it into an "Outgoing" correspondence box.

C. A. WEBBER and W. J. KING conferred with the Bureau of Ships in Washington on cable matters.

AT FORT STORY and Fort Monroe, Va., R. S. GRAHAM and D. T. BELL discussed apparatus with the Coast Artillery Board. They also conferred with LIEUT. COL. A. W. CLEMENT who is on a military leave of absence from the Laboratories.

THE ANNUAL SPRING CONCERT of the Bell Chorus will be presented at Town Hall on Tuesday evening, May 9. Tickets may be purchased from MISS HILDA MULLER, West Street, Ext. 1902, or ALLEN BLACKMAN, Graybar-Varick, Ext. 2024.

H. H. STAEBNER studied cord development problems in Baltimore.

D. T. BELL is president of the University of Cincinnati Co-op Alumni Club of N. Y.

H. H. GLENN and J. C. WRIGHT were in Chicago to discuss wire and cable matters.

F. W. CLAYDEN visited the New Haven Office of The Southern New England Telephone Company on problems relating to step-by-step equipment.

J. A. CARR, in Philadelphia, attended an A.S.T.M. meeting of the subcommittee on glass insulators.

A. H. SCHIRMER was at the Bureau of Standards in Washington in connection with Safety Code matters.

THE LABORATORIES were represented in interference proceedings before the Primary Examiner at the Patent Office in Richmond by G. H. HEYDT and W. M. HILL.

P. W. SHEATSLEY and E. L. GETZ were in Chicago in connection with a study of line load control for the Oakland crossbar office.

A. E. PETRIE, V. T. CALLAHAN, J. L. LAREW and F. T. FORSTER paid a visit to the Plant Engineering Agency and to the Signal Corps Supply Depot in Philadelphia on war projects.

W. G. SCHAER and A. W. TUCKER visited the Signal Corps Plant Agency in Philadelphia to discuss Army switchboards.

"THE TELEPHONE HOUR"

(NBC, Monday Nights, 9:00 P. M., Eastern War Time)

APRIL 10, 1944

Les Filles de Cadix	Lily Pons	Delibes
I Love You	Orchestra	Porter
Vocalise	Lily Pons	Rachmaninoff
The Sorcerer's Apprentice	Orchestra	Dukas
Villanelle	Lily Pons	Dell'Acqua

APRIL 17, 1944

Let's Make Tomorrow Today	Nelson Eddy	Heymann
En Bateau	Orchestra	Debussy
Thy Beaming Eyes		MacDowell
Tally-Ho		Leoni
Water Boy	Trad.—Arr. Robison	
Nelson Eddy		
Symphony No. 4—14th Movement	Tschaikowsky	
Orchestra		
Do Not Weep, My Child	Rubinstein	
Nelson Eddy		

APRIL 24, 1944

Czardas from "Coppélia"	Delibes
Orchestra	
Agnus Dei	Bizet
Marian Anderson	
If There Is Someone Lovelier Than You	Schwartz
Orchestra	
Believe Me If All Those	Traditional
Endearing Young Charms	
Oh! What a Beautiful City	

Dere's No HIDIN' Place Down Dere

Marian Anderson

La Cenerentola Overture

Rossini

Orchestra

My Heart at Thy Sweet Voice

Saint-Saëns

from "Samson and Delilah"

Marian Anderson

MAY 1, 1944

Marjorie Lawrence will be the guest artist

Women of the Laboratories



Marjorie Albers (above) of Central Files is responsible for the inspection and checking of all correspondence before it is released to be filed in the correspondence folders. Because of her general knowledge of filing procedures, Miss Albers substitutes at the Graybar-Varick building during absences in the filing group



The girls above are Marilyn Daniels (top) and Helen Schaefer (bottom), of the Research Staff Department. Miss Daniels records orders for Laboratories equipment and plots running graphs showing the expense incurred weekly. Miss Schaefer is responsible for maintaining case information records and information involving transfers of engineering expense

PATENTS HAVE BEEN a byword in MARTHA PUGH's family since she was a child, so her becoming a member of the Patent Staff of Bell Laboratories seems a logical sequence. Mrs. Pugh was born in Washington and moved to New York when her father, a patent attorney, transferred here. After completing her schooling in the city she went to the University of Colorado mostly, she says, because both of her parents come from that state. In 1934, upon her graduation with a B.A. in physics, she joined the Bureau of Standards in Washington. Within a year she married Wallace R. Pugh of Long Beach, California, and together they did graduate work at the University of Michigan. There in 1936 she received her M.S. degree in physics and took courses in journalism while her husband specialized in naval architecture prior to his becoming attached to the staff of the Navy's Superintendent of Shipbuilding. Their first son, John Clifford, was born in 1939 and their second, William Wallace, two years later. In 1942 she became an instructor in physics at New York University and, during the three semesters in which she taught, did advanced work in mathematics and electronics there and at Columbia. She held this position until she came to the Laboratories

in August, 1943. As a new member of the Patent Department, Mrs. Pugh assists in many phases of patent work in the high-frequency and electronic fields. She helps to make searches and novelty studies and she also assists in the amending of patent applications.

Most of her free time on Saturdays and Sundays is spent with her children, who are now of nursery school age. She is interested in music, having studied piano during her years at school and college, and in hiking and mountain climbing. When she had more leisure she was active in civic work in her community and was at one time a member of the Grand Jury in Queens. For several years she was a member of the Queens County Republican Committee and was a delegate to the state conventions. Mrs. Pugh is a member of Pi Beta Phi, the national honorary society for Senior College Women; the Women's Fraternity Mortar Board; Sigma Pi Sigma, the national honorary physics society; and the American Association of University Women.

* * * * *

A GRADUATE of Northfield Seminary, ETHEL BLOCKER attended art school as well and worked as a receptionist before becom-



Pictures of Martha Pugh's sons grace her desk



Ethel Blocker with J. A. Seifert, one of the instructors in the advanced drafting course

ing a member of the Laboratories. After three years as an operator her interest was drawn from the Plant Department PBX board to the drafting board in the Research Staff Department. In March she completed her advanced training given over a period of fifteen weeks, during business hours, by the Personnel Department and she is now a full-fledged draftswoman. Her keen sense of proportion, the exactitude of her craftsmanship and her willingness to work have resulted in her becoming not only a welcome but also a valued member of the Research Drafting Department group.

Miss Blocker's main outside interest is tennis. She lives near the famous Forest Hills courts with a roommate who also thrives on the game. In the past she has been active in giving and directing church pageants. She also likes to dabble in writing and painting, but solely, she says, for her own amazement.

BECAUSE MARY FARRELL's thoughts are with her fiancé in the A.A.F. in England, the hundreds of young men in the Bell Telephone Laboratories School for War Training hold no special interest for her. Mary came to the Laboratories' Transcription Department early in 1941 and after a few months was put on special assignment as stenotypist at the School. A resident of Yonkers, she attended the local high school and the Yonkers Collegiate Center.

Some while ago she took one of the Laboratories' courses in First Aid and since then has been the guardian of the First Aid cabinet for the School areas. The First Aid business is brisk on windy days when

she has to remove particles from many of the soldiers' eyes. There is always some work to do in caring for minor burns and scratches among the trainees. Mary does her share of knitting for the boys and, besides enjoying chess, is a pianist in her own right. She adds, however, that she prefers other people's music for dancing to playing her own.

* * * * *

IN THE Payroll Department SHIRLEY SMITH is responsible for preparing and issuing salary payments to members of the



Mary Farrell takes dictation from R. N. Hunter



CORA C. VAN BERGEN

Laboratories who have terminated their service. She also arranges payroll salary adjustments for absences at one's own expense, as well as absence reimbursements and Benefit Plan payments.

Miss Smith has been with the Laboratories four years. A native of Southampton, she returns there every summer for her

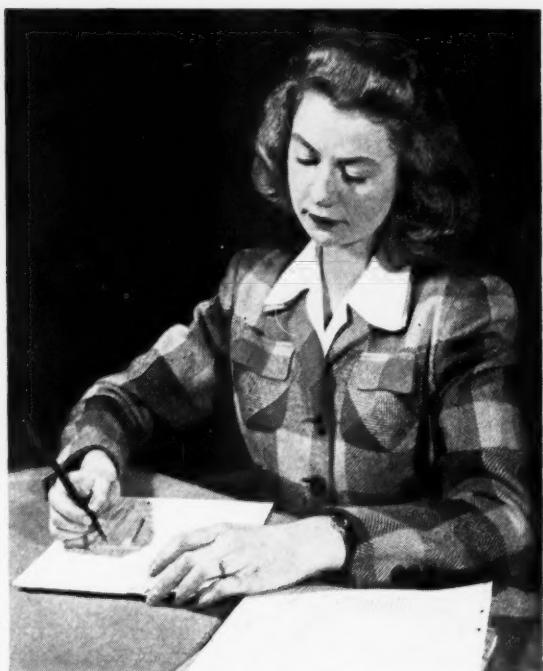


MARY SHERWOOD

vacation and for the rare week-ends she has off. She is an all-round outdoor girl but finds little time for such activities now when her working week is six days. However, because she is an ice-skating enthusiast—racing is her specialty—she takes time to practice one evening a week. Another girl from the Laboratories shares her three-room Brooklyn Heights apartment, its chores and its comforts. At home she is an avid reader, but reading can be done only after she has written to the Navy man to whom she has recently become engaged.

* * * * *

MARY SHERWOOD, a student at Bennington College, spent her mid-winter vacation



SHIRLEY W. SMITH

working in the Laboratories. A messenger in the General Service Department, she was assigned to the West Street Reception Room.

* * * * *

WIFE OF AN ARMY newsreel photographer, CORA VAN BERGEN is one of the many girls doing essential non-glamorous work in the Laboratories. Mrs. Van Bergen—or "Billie" as she is better known—is an assistant store-keeper in the self-service stockroom on the sixth floor at West Street. This stockroom is one of seventeen operating stockrooms located in the various Laboratories buildings in New York and New Jersey.



FIGHTERS ON THE HOME FRONT

Girls in the Development Shops of the Laboratories are doing vital work on experimental models of war developments. Above are Leona Chambers (left) and Carter Delafield (right), two new recruits who have recently completed a full-time six weeks' shop training course. The other girls, members of the Murray Hill Shop, have each had over one year's experience in their work: Evelyn Kelly (right), Grace Scheiderman and Viola Klischer (below)



She helps people to find items which they need, requisitions material from other stockrooms, keeps records, takes inventory, checks receipts, puts the stock away, and, in general, keeps the stockroom in tip-top order.

Mrs. Van Bergen's artistic ability and good taste in decorating and in combining flattering and unusual color schemes for her friends' apartments, as well as for her own, are well known. She is a collector of rare Dresden and Luxembourg pitchers and of miniature shoes and boots which have come from all over the world—the top section of her secretary serves as a display case for them. She also has a splendid collection of pictures taken by her husband, a former Pathé cameraman, now in the Pacific theater of war.

Because her father's business took him all over the country, she attended private schools in seven states. A capable horsewoman and swimmer, she is also fond of dancing. She is a sister-in-law of MARY VAN BERGEN in the Transportation Group and a niece of LOUISE VAN BERGEN in Messenger Service. One of her grandparents, known as the copper king of Montana, was a friend of Alexander Graham Bell "from the time that Bell was a little Bell," as Grandfather Coram put it in letters which Mrs. Van Bergen now has.

Will You Fight on the Farm Front?

Will you volunteer to fight on the Farm Front for one or two weeks of your vacation?



Three and a half million men and women are needed urgently to harvest this year's crop. Our fighting men on the islands and continents of the world are looking to you for their rations. Other men are willing to risk their lives to get the convoys through, but the food ships won't sail unless the crops are harvested and kept



moving up to the docks. If the food supply should fail—the work of members of the Laboratories, of shipbuilders, aircraft workers, miners and munitions makers—and the work of our fighting men—would all be in vain.

The United States Employment Service of the War Manpower Commission is looking for "Victory Vacationists" to spend their vacations harvesting es-

ential crops and working in the essential canneries that process food. For the most part "Victory Vacationists" will be housed in camps or other approved centers and will work by the day for a large number of farmers in a vicinity. In some cases individual workers or groups of two or three may live at the home of the farmer employer.

They will be paid the prevailing wages for inexperienced harvest hands in the area to which they are sent. They must pay for their own board and room at minimum rates. Members of the Laboratories who harvested last year's crop say that they "broke even" for their vacations. Those volunteering to work two full weeks will have their fares paid one way.

Farming is a real job, not a rest cure, yet it can be a healthful happy vacation. For many who are confined to desk or bench work for long hours all year, it will be a means of storing up reserves of health, sunshine, and energy for the coming year. At the same time, those who volunteer will be helping to get food through to their relatives in service. Bush berries and currants will be ready for harvest in July; lettuce, beans, tomatoes and peaches in August; apples, carrots and corn in September; pears, grapes and potatoes in October.

Pamphlets with information for "Victory Vacationists" will be found in the Lounges at West Street, Murray Hill and Whiphany. For those interested in spending their vacations harvesting the crops in either New York or New Jersey, complete details may be obtained from Mrs. C. A. Smith, Room 159 at West Street, Extension 1149.



April 1944

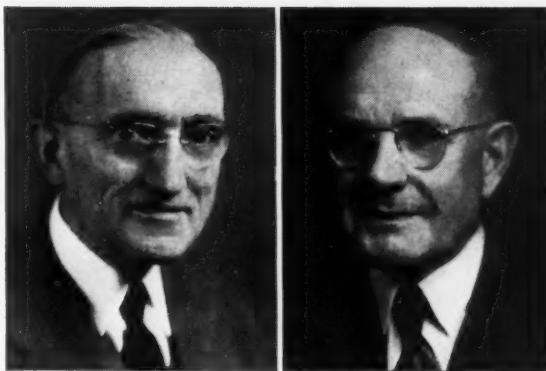
Retirements

JACOB SAUER of the General Accounting Department retired on February 29 at his own request following twenty-six years of service with the Western Electric Company and the Laboratories. From 1897 to 1918 Mr. Sauer was an accountant with the H. Herrman Furniture Company. He then joined the bookkeeping group of the Western Electric Company's Engineering Department and was placed in charge of this group in 1919.

With the incorporation of the Laboratories in 1925 Mr. Sauer continued in charge of the group which now became responsible for the various books of account of the Laboratories. Later he was given the title of Corporate Accountant. Mr. Sauer supervised the preparation of Federal and state tax reports and the handling of all records involved in the Plan for the Protection of Insurance of Employees Engaged in Insurance-Invalidating Activities. This plan covers flying activities in connection with experimental and engineering work and more recently has been expanded to cover other insurance-invalidating activities brought about by the present war.

* * * * *

EDGAR M. MATTHEWS of the Outside Plant Development Department with forty-one years' service in the Bell System retired on March 31 under the Retirement Age Rule. Mr. Matthews was graduated by Clemson College in 1901 with the B.S. degree. He was an instructor at Clemson the



JACOB SAUER

E. M. MATTHEWS

following year, during which time he also did graduate work. He received the degree of Electrical Engineer from Clemson in 1928.

Mr. Matthews joined the New York Telephone Company in 1902 in its Engineering Department's student course, following which he engaged in outside plant work, particularly the development of apparatus and the preparation of specifications. He also prepared estimates of subscriber station growth based on field studies. In 1910 he spent a year in a special survey of the fire alarm system of New York City and in this connection was responsible for the design of most of the equipment other than the central-office apparatus.

A year later Mr. Matthews transferred to the Engineering Department of the A T & T where he served in the outside plant group until he joined the D & R on its organization in 1919. Up to the time when the D & R was merged with the Laboratories, he was

During the Months of January, February and March the United States Patent Office Issued Patents on Applications Previously Filed by the Following Members of the Laboratories

T. Aamodt	H. W. Dudley	L. G. Hoyt	R. F. Mallina (2)	W. A. Rhodes
W. M. Bacon	W. H. Edwards	F. A. Hubbard	C. O. Mallinckrodt	C. D. Richard
R. H. Badgley	J. C. Field	O. B. Jacobs	W. H. Martin	V. L. Ronci
H. L. Barney	G. W. Gilman	J. A. Kater	W. P. Mason	C. H. Rumpel
H. M. Bascom	F. J. Given	L. W. Kelsay	R. C. Mathes	J. N. Schive
J. Baumfalk (2)	F. Gray	D. H. King	D. A. McLean	J. W. Schmied
J. A. Becker	W. W. Halbrook (2)	R. E. King (2)	J. M. Melick	J. H. Shuhart
B. S. Biggs	J. J. Harley	T. G. Kinsley	O. S. A. Mesch (2)	T. Slonczewski
H. S. Black	J. B. Hays	W. A. Knoop	O. R. Miller (2)	K. D. Smith
H. W. Bode	G. Hecht	J. G. Kreer	P. B. Murphy	G. K. Teal
E. Bruce	I. H. Henry	W. Y. Lang (3)	G. L. Pearson	C. L. Van Inwagen
A. J. Busch	R. E. Hersey	H. T. Langabeer	K. H. Perkins	H. E. Vaughan
O. Cesareo	F. H. Hibbard	J. B. Little	L. F. Porter	A. H. Volz
V. M. Cousins	S. C. Hight	G. H. Lovell	W. T. Pritchard	E. Vroom
S. T. Curran	W. H. T. Holden (4)	C. W. Lucek	O. E. Rasmussen	J. W. West
W. A. Depp				R. O. Wise

concerned with the development of cable apparatus, including cable terminals, protector mountings and loading coil cases. Since 1934, in the cable apparatus engineer's group of the Outside Plant Development Department, he was engaged in outside plant work in connection with the development of loading coils and associated apparatus. He was intimately associated with the loading problems involved in the type-J carrier system. More recently his work has been on important cable projects of the Bell System under war conditions and on certain Army projects.



Another example of wartime streamlining is the semi-booth for public telephones. Designed to be attached to a wall, the new model is expected to be useful in semi-exposed locations, especially in mild climates

Semi-Booth Undergoes Trials

A model of the semi-booth shown in the accompanying illustration was exhibited at the recent New York conference of Bell System operating vice-presidents, and a half-dozen of the booths are undergoing trials at widely separated points in the country. The booths, made of wood, with Masonite panels and roof, offer the obvious advantage of a substantial saving in materials and manufacturing effort. They are expected to be useful, at least for short-duration installations, in mild climates and semi-exposed locations.

There is no door to the booth itself. But an inside door closes off the telephone compartment, thus protecting the coin machine from dirt. When the door is opened, a light comes on over the telephone. The fact that there is no floor to sweep will be welcomed, no doubt, in areas where "housekeeping" difficulties have been experienced.

In the present emergency, pay stations afford the only telephone service available to many thousands of families living in small dwellings near war production centers. Since few good indoor locations can be found, many of the telephones are placed in conveniently located outdoor booths, often on the porches of buildings.

Direct Circuits to West Coast Trebled

To help meet the growing demand for long distance telephone service between the West Coast and other parts of the country, the number of direct Long Lines circuits and circuit groups serving this war-busy section has been increased more than threefold over the 1940 total.

This trend, to go straight to the point by setting up additional direct circuits between West Coast cities and others further east, is in step with the Bell System's overall effort to expedite the completion of calls and to conserve circuit, operating and equipment time.

Today there are some 500 direct circuits and 88 circuit groups connecting the Pacific Company territory with the rest of the country, as compared with 160 direct circuits and 27 circuit groups in 1940. Long Lines traffic people believe that by the end of 1944 a total of 900 direct circuits will be needed to handle the Pacific Coast volume.

However, in view of other war requirements, it may not be possible to provide quite such an increase during this year.

Western Electric Equipment for U.S.S. *Wisconsin*

When the newly launched U.S.S. *Wisconsin* goes into action against the enemy, the success of this super-battleship will depend in a large measure upon shipboard communication equipment developed by Bell Telephone Laboratories and manufactured by the Western Electric Company.

Like many other warships, from destroyers to aircraft carriers, the *Wisconsin* will use Western Electric communication-systems to transmit orders and announcements of every kind aboard ship, according to Navy officials in charge of purchasing and installing this equipment for the Navy's Bureau of Ships.

Separate communication-systems are important elements of the fighting equipment aboard the mighty dreadnaught. These interconnect every battle station by sound-powered telephones and provide a general announcement system through which messages reach every quarter of the ship over strategically placed loudspeakers.



This window display which features the Laboratories is now on tour among Illinois Bell commercial offices

Eight separate battle announcing systems, more than 355 individual loudspeakers and 20 transmitter stations comprise the set-up. Special oscillators generate pre-arranged tones and signals.

The sound-powered telephone system, which depends on the voice of the speaker

Excerpts From Western Electric Annual Report

With a world-wide and fast-moving war demanding new and greater production for the military forces, the Company's already heavy war program increased steadily throughout 1943.

Of outstanding importance to the war effort were the continued development and manufacture of highly specialized radar and electronic devices essential to the waging of modern warfare. The growing demands also included much radio and telephone equipment specially designed for long distance and other wartime communication.

* * *

Sales totaled \$714,338,000, as compared with \$573,956,000 in 1942. Sales to the Government increased steadily throughout the year and amounted to \$596,112,000 as compared to \$309,013,000 for the previous

year. At the end of the year unfilled Government orders amounted to over one billion dollars.

* * *

The ever-changing tactics of military operations demanded more and more specialized developments in the electronic and communication fields. Working in close collaboration with its research and engineering development affiliate, the Bell Telephone Laboratories, whose vast resources were devoted almost entirely to this war work, the Company was constantly confronted with new and complex manufacturing requirements involving new processes and enlarged facilities. Radar, together with radio, telephone, and other newly developed electronic equipments, were the predominant items in the Company's war program.

to generate electricity for the circuit, includes 1,250 headsets and 950 handsets.

The *Wisconsin* will displace 52,000 tons when loaded for sea duty, according to the unofficial publication, *Jayne's Fighting Ships*.

Telephone Talk

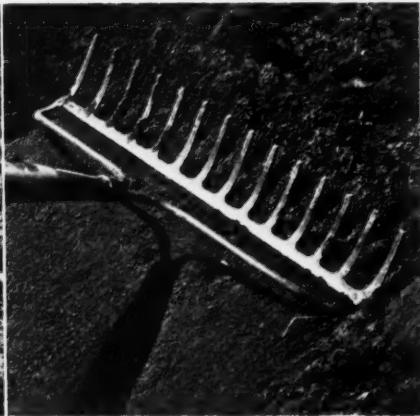
Telephone linemen are used to climbing telephone poles with spurs, or riding over empty space supported only a cable strand, but for a recent job in Vermont they had to acquire the seagoing agility of sailors. It was a matter of making a transposition in



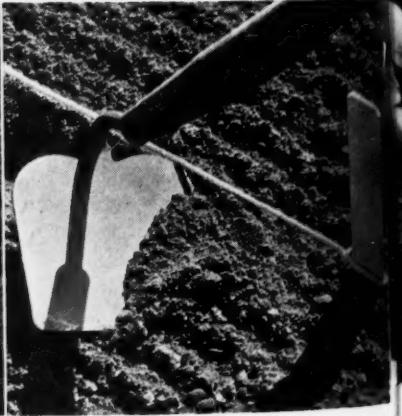
Your soil must be well spaded or plowed. Drive spading fork or spade straight down into the ground with the weight of your body. Dig to a depth of eight to twelve inches.



Clods are inevitable. Many can be broken up by tamping them with the flat side of your rake. Clods too hard to break, as well as stones and rubbish, should be raked to one side and carted away.



Use your rake, teeth-side down, to pull the soil where you want it, filling furrows and hollows. Then, too, careful raking improves soil texture. For finishing, turn rake on its back and smooth.



Make a trench for large seeds by pulling the corner of your hoe through the soil at the depth indicated on your seed carton. Hold the hoe evenly against the guide cord to keep your trench straight.

a type-C carrier line. The transposition, however, fell directly over the Winooski River, which at that point was 400 feet wide. Transpositions are temperamental, and must be made at their allotted point—"or else." The "or else" in this case meant extensive changes in the transposition layout which could not be justified. Nothing daunted, the New England Company's linemen constructed a 20 x 23-foot raft, and on it erected a 30-foot tower—not of Babel—to reduce the babble in the telephone circuits overhead. By moving the raft in midstream directly under the point where the transposition was to be made, and constructing a "fighting top" just below the line wires, they then made the transposition in all the comfort that a sailor could ask. The tower was made of crossarms bolted together, and salvaged after the job was done.

Movie Club Active

The Motion Picture Camera Club was organized to stimulate interest in the making of amateur motion pictures. To accomplish this it was proposed to set forth the fundamentals of picture making and to demonstrate them through the projection of pictures made by experienced amateurs. The educational part of this plan is being presented in the Club magazine *Movie Club*

How to Prepare Ground and

News. In order to procure pictures to illustrate the application of these principles the Club called upon nationally known workers in the home movie field to screen their prize-winning films. This policy has given our members an insight into the correct procedures to follow in making an acceptable picture and has afforded many evenings of enjoyable entertainment. This is attested by the ever-increasing attendance.

The type of program is illustrated by the proposed one for the meeting on April 26 when there will be offered the following 8-mm films: *Canadian Holiday* and *Mr. Hitler Never Loses??* by Joseph Hollywood, *Abroad at Home* by Archibald McGregor, and *Gold Rush, 1942*, by Victor Ancona. All members of the Laboratories are invited to the meeting.

Another activity of the Club is the holding of an annual contest. There are no limitations as to the number or length of films each contestant may enter, but films entered in a previous Bell Laboratories contest are not eligible.

The contest is divided into three classes: (1) Story or Scenario films, (2) Documentary or Family films, (3) Travel or Pictorial films. Each contestant should indicate the group in which it is to be placed. The Committee reserves the right to reclassify.

Plant Your Victory Garden



When planting larger seeds, take a few at a time in your hand and drop singly into the bottom of the furrow. Directions on your seed carton will tell you how far apart to space each seed.

Cover seeds by pulling soil into the furrow with your hoe. Don't cover too deeply. Watch planting depth for each kind of seed as given on the backs of cartons and packets.

Tamp soil along the row with flat of your hoe. This brings seed and soil into close contact to hasten germination. If soil is dry, water the rows with a sprinkling can, but sprinkle gently.

Films will be judged by competent cinematographers from outside the Laboratories. Eight and 16-mm films will not be segregated but will be rated on their photographic and interest merits.

Prizes will be given in the form of war stamps for the three best in each class and a grand prize for the best film submitted. Only one award, however, will be given for any one film. Entries must be submitted to H. L. BOWMAN, Section 31, at West Street, by May 1. The prize-winning films will be shown at the final meeting on May 17.



Plant small seeds in a shallow furrow. Hold packet between thumb and finger and tap gently. Sow seeds thinly as shown to avoid tedious job of thinning later. Rows should be kept straight by marking off each with a cord stretched tightly between stakes at each end of row.

All photos courtesy of Ferry-Morse Seed Company.



Signal Corps Photo

The M9 Electrical Gun Director (center), a development of the Laboratories, is now in use in all theaters of the war. Upper right, Italy; this gun was associated with the Director shown. Upper left, Iceland; lower left, South Pacific; lower right, West Indies. All the guns are 90-mm weapons of the type shown at Murray Hill last November. They are used both in anti-aircraft and anti-tank combat

Telephone Sets for Noisy Locations

By J. W. FOLEY
Transmission Engineering

BOOTH the intensity and the frequency composition of surrounding noise affects one's ability to hear through the telephone, but these factors alone do not permit the influence of noise to be evaluated. Noise disturbs the understanding of speech both by a distracting effect and by actually "masking" the speech; and the situation is further complicated by there being several paths over which the noise may travel. The distracting effect is predominantly psychological, but the masking is physical. A person who habitually uses the telephone in noisy locations usually becomes able to overcome the distracting effect, but masking must be reduced by physical means.

The three main paths over which noise acts are known as the "side-tone" path, the leakage path, and the other-ear path. Noise following the side-tone path is that which falls on the telephone transmitter, and is transmitted to the receiver through the local telephone circuit. The anti-side-tone telephone set,* now in common use, introduces a considerable loss in this path, and has thus greatly reduced the effect of noise on the telephone user. With the present instruments, the complete elimination of the remaining side-tone would improve reception by only a few db. Noise following the other-ear path reaches the consciousness by way of the ear not covered by the telephone receiver. It can be reduced only by blocking that ear. Noise acting over this path, however, produces much less disturbing effect than noise at the ear receiving speech, and ordinarily is not serious. Leakage-path noise

is that reaching the ear to which the receiver is held by passing between the receiver and the ear. It can be appreciably reduced by holding the receiver tightly to the ear, or by employing a specially designed, tightly fitting receiver cap.

In designing a telephone set for noisy locations, therefore, neither the other-ear or leakage-path noise can be reduced by changes in the telephone circuit itself. Noise passing over the side-tone path, however, can be reduced, and its total disturbing effect can be decreased in either or both of two ways: by increasing the loss in the side-tone path itself, or by increasing the speech level relative to the noise. Which of these two methods is most desirable will depend to a large extent on the loudness and frequency composition of the noise. If the frequencies are predominantly those readily passed through the side-tone path, and the noise level is not too high, a reduction in side-tone is generally effective. If the major noise components, on the other hand, are those that readily pass through the leakage path, or if the noise is so great that the other-ear and leakage paths become important, additional gain in the speech path

*RECORD, July, 1939, p. 347.



will be the more effective way of handling.

In view of this situation, a new telephone set for noisy locations has been made available. It has two forms: one employs an amplifying arrangement, which raises the receiving level without materially changing

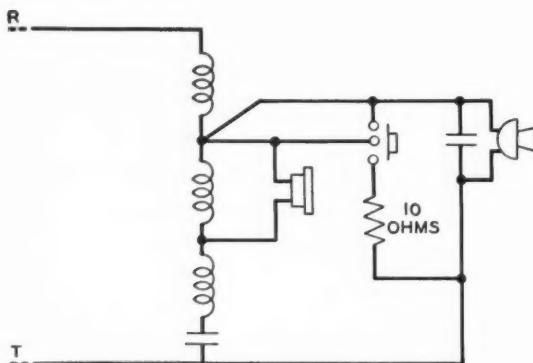


Fig. 1—Simplified circuit for the non-amplifying arrangement

the level of the noise; the other is a non-amplifying arrangement, which reduces the noise passing through the side-tone path, but does not increase the received speech. Both employ a low resistance that is shunted across the transmitter during the listening periods, but the former also provides an amplifier to increase the level of the received speech. With either arrangement the handset is replaced by a D-173198 handset. This is similar to the commonly used F1 handset except that it incorporates a push-button in the handle which is pressed for listening. With the non-amplifying arrangement, this handset is the only addition made, but with the amplifying arrangement, a D-165582 key and one No. 6 dry cell are also required. The key unit includes a 111B amplifier, which is the amplifier used with the telephone set for the hard of hearing* and also a 1500-ohm resistance, which is in series with the amplifier input, but is short-circuited when the push-button on the handset is pressed. The dry cell may be mounted in any convenient place and is wired to the key unit. The drain on the battery while in use is only 10 or 15 milliamperes.

A simplified circuit diagram for the non-amplifying arrangement is shown in Figure 1. This is the regular anti-side-tone handset

*RECORD, October, 1942, p. 45.

circuit except for the push-button and the 10-ohm resistance. A resistance to this value produces the reduction in side-tone desired, while a short-circuit would make the circuit sound dead, and the distant subscriber might think he had been disconnected. During listening periods the push-button is pressed, connecting the resistance across the transmitter, thus reducing the side-tone by about 12 db. The result is an increase in the effective receiving gain by 2 to 4 db, depending on the existing side-tone and on the noise level.

Where the noise conditions are such that satisfactory hearing cannot be secured with the non-amplifying arrangement, the D-165582 key is added, and the circuit is arranged as shown in Figure 2. In this diagram s₁, s₂, and s₃ are three springs of the key, which are all operated at the same time when the lever is moved. With the lever in the "down" position as indicated, the amplifier is disconnected, and the circuit is effectively the same as in Figure 1. With the

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1911, J. W. FOLEY immediately joined the Western Electric Company at Hawthorne. Upon the completion of the student course, he entered the Transmission Laboratory at New York, where he was concerned with general transmission studies. His work soon became

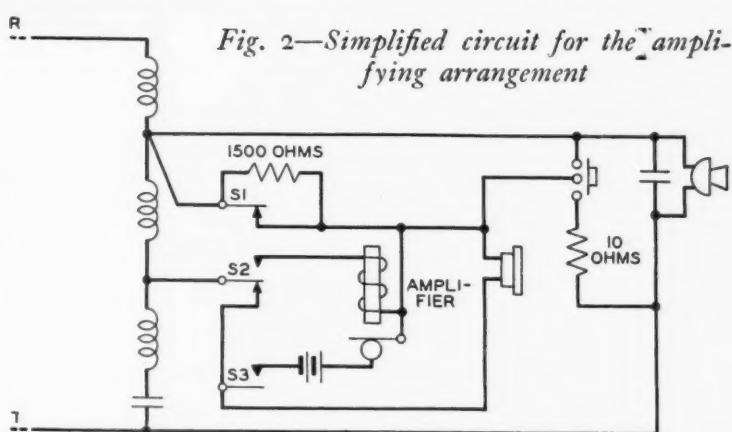
centered upon telephone sets and their associated circuits. He has been intimately associated with the development of the anti-side-tone telephone sets now standard for both subscribers and operators as well as many sets for special purposes such as train dispatching, amplifier sets for the hard of hearing, and loudspeaker systems for both intercommunicating and regular telephones. More recently he has participated in the development of closed-core induction coils for operator and subscriber sets, of acoustic shock prevention devices, and in further studies for the improvement of subscriber telephone sets and their associated apparatus.



key "up," the input of the amplifier, in series with the 1500-ohm resistance, is substituted for the receiver of Figure 1, while the receiver is connected to the output of the amplifier. Under these conditions the 12 db gain of the amplifier is practically offset by the loss through the 1500-ohm resistance, and thus listening conditions are the same as those encountered with the standard telephone set.

When the push-button in the handset is pressed, however, the 1500-ohm resistance is short-circuited, and the 10-ohm resistance is shunted across the transmitter. As a result, the 12-db gain of the amplifier is effective in both the receiving and side-tone paths, but the side-tone is decreased 12 db by the resistance shunting the transmitter. The net result is to leave the side-tone at about the

Fig. 2—Simplified circuit for the amplifying arrangement

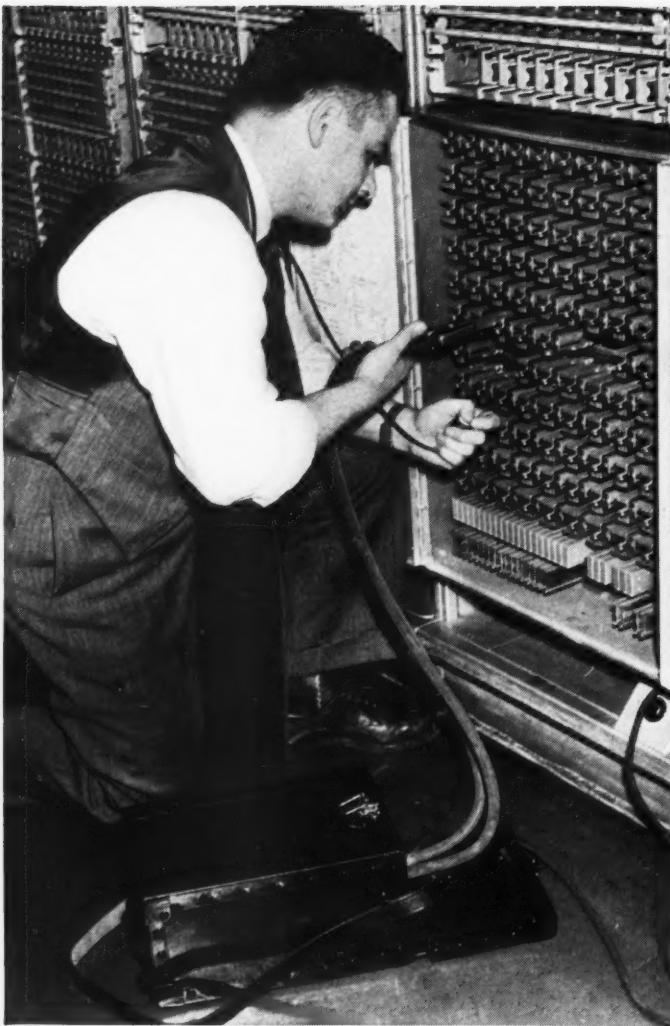


original level, but to increase the incoming speech 12 db, thus improving the receiving efficiency by this amount.

With these two arrangements available, it is felt that satisfactory transmission can be furnished even in very noisy locations where the improvement that is made possible by the anti-side-tone telephone set alone does not prove adequate.



C. W. Mattson of the Microchemical Laboratory employing apparatus recently developed to detect sulfide sulfur in unusually low concentrations. Minute amounts of sulfur can exert a marked influence on many materials, and when present as sulfides on surfaces can profoundly affect the mechanism of interfacial reactions. This is particularly true of communication equipment, where delicate contacts and vacuum tubes are both subjected to sulfur "poisoning." With this apparatus as little as one millionth of a gram of sulfur can be determined.



Relay Contact Welder

By W. T. PRITCHARD
Apparatus Development

from its supports or dismantling it. With this welder, contacts can be renewed much faster and more conveniently than formerly and considerable amounts of critical materials and labor are saved. In this development O. S. Mesch collaborated with the author.

The welder supplies a heavy current, generated by a step-down transformer from 110-volt a-c supply, to a pair of thin-nosed welding pliers which can be inserted between the relay springs. One of the pliers' jaws holds the new contact metal and the other presses against the back of the spring to which the contact is to be welded. A push-button closes the circuit of a power relay to make the weld, and the welding interval is controlled automatically

and precisely by another relay with delayed action. Heavy flexible cables connect the transformer to the welding pliers. Power is supplied through an ordinary plug and cord. There is also a stripping tool to remove defective contacts, a set of insulating guides to position contacts on the different relays, an orange stick which spreads the springs to facilitate welding, and tweezers for handling the contacts. The current supply unit is mounted in a carrying case and there is also provided a box for the small tools and the new contacts required.

To open the pliers, their handles are squeezed. These handles are insulating sleeves through which pass the conductors that carry the welding current. A block of phenol fiber **B**, Figure 1, serves as a part of the hinge for the pliers' jaws and insulates them from each other. One of these tips **A** is adjustable laterally to bring the point **P**

MANY electrical contacts are closed and opened in relays and other switching devices that operate in telephone circuits each time a subscriber calls. The contacts are usually made of precious metal welded onto springs near their outer ends. These metals provide dependable service for a long time, but eventually mechanical abrasion and electrical erosion require that they be replaced.

Most relays have spring pile-ups which require taking apart to recondition their contacts. It has been past practice to remove the defective apparatus from the frame supports and return it to repair shops to be dismantled and reassembled with springs equipped with new contacts. To reduce the time required to remove and recondition this equipment, the Laboratories has developed a welding machine which replaces worn contacts without taking the apparatus

opposite the place on the spring where the contact is to be welded. There are four small perforations in the end of the other tip c, into any one of which is inserted a tab on the new contact to hold it for welding. The aperture chosen depends on the design of the springs of the switching device. Tip c is a fixed electrode which is removable by loosening a thumb-nut. A guide g, mounted in the end of electrode c, fits the spring being reconditioned and positions the new contact. A set of these guides is provided to accommodate the springs of various apparatus.

Defective contacts are sheared off close to the spring by the stripping tool, which has a sliding hinge. The spring to which a contact is to be welded is separated from its spring with the orange stick to provide clearance.

Pressing the control button c, Figure 2, completes a circuit through the auxiliary transformer A and the rectifier R and operates the power relay P. This closes the circuit through the welding transformer W to the electrodes and supplies a heavy current at very low voltage for a brief time to weld the contact to the spring. Operation of the power relay also closes a circuit to the time-control relay T which disconnects the current from the pliers after the interval required to make the weld. The timing relay locks operated through its make contact, which is under the control of the starting button, thus preventing the re-operation of the power relay until the button has been

released and pressed again. Release of the starting button restores the timing circuit to its initial condition. After the welding operation the tab on the contact may be removed with tweezers.

With the new welder an experienced repairman can weld many new contacts on relay springs in the time usually required to replace one defective relay.

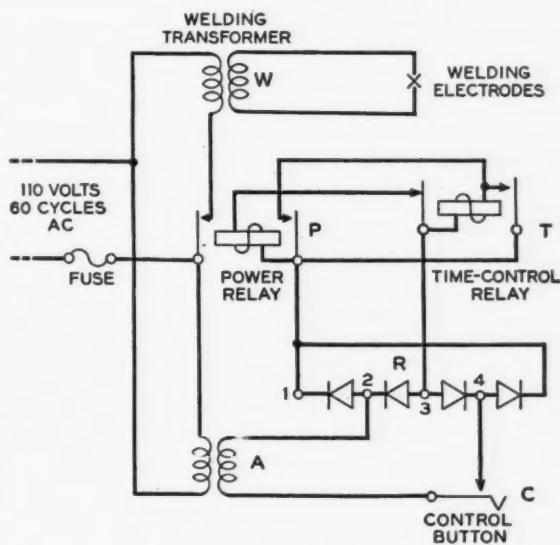


Fig. 2—Pressing the control button C completes a circuit through the auxiliary transformer A and the rectifier R and operates the power relay P, which closes the circuit through the welding transformer W. The delayed-action relay T determines the welding time

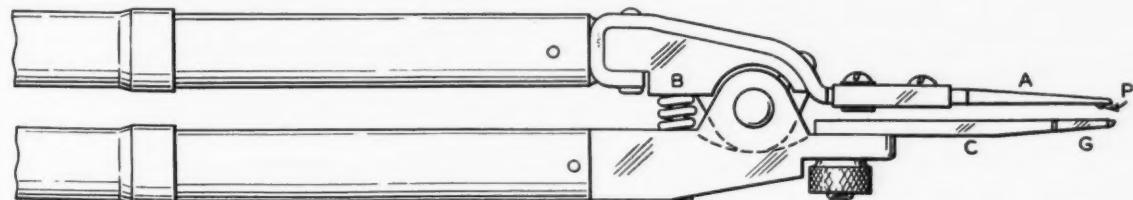


Fig. 1—A pair of thin-nosed welding pliers is inserted over the spring whose contacts are to be renewed. One of the jaws of the pliers holds the contact metal; the other presses the spring against it



An Automatic Vibration Analyzer

By F. G. MARBLE
Commercial Products Development

ONE of the potential causes of failures in an airplane power plant or the airplane structure itself is excessive vibration. Every effort is made in the design of the power plant and its mounting and of the airplane structure to reduce the number of modes of vibration which would be excited to objectionable amplitudes. In spite of these efforts, it is desirable to measure the power plant and airplane vibration characteristics in flight, preferably on the prototype airplane, to insure there are no vibrations present of sufficient magnitude to cause fatigue failures in any parts. Many types of vibration-measuring equipment have been used in these vibration surveys and, while each has many merits, there has been a great deal to be desired in measuring equipment as regards the speed with which vibration data can be obtained and analyzed. This is particularly true in the case of instruments for measuring and analyzing engine vibration where it is usually important to obtain at each of a number of engine speeds in the operating range the amplitudes of vibration at each of several frequencies. The Laboratories has developed an automatically tuned wave analyzer to meet the needs of the Pratt and Whitney Aircraft Division of United Aircraft Corporation, who desired apparatus that when

used in conjunction with suitable vibration pickups would measure the amplitude of vibration at a frequency equal to any predetermined multiple of engine rpm, even when the engine speed is continuously changed. This analyzer can be used with a recorder, which has also been developed to meet the needs of Pratt and Whitney Aircraft, to draw curves of the amplitude of vibration of selected orders of frequency as a function of engine speed.

In Table I are listed the orders (or frequencies in terms of multiples of engine rpm) for which the analyzer tuning was desired. Provision is made for five additional orders to be specified later. The twenty-three orders listed were included by request of Pratt and Whitney, and were based on the possible exciting forces in a number of different engine-propeller combinations. For the most part, power plant exciting forces originate from inertia unbalances in the engine or propeller, from forces produced by the burning gases in the cylinders, and from aerodynamic forces acting on the propeller. These exciting forces usually occur at frequencies corresponding to definite multiples of engine rpm. Since the engine speed is assumed to range from 500 to 3,000 rpm, the actual frequencies involved will cover the range between the lowest order at the lowest engine speed to the highest order at the highest engine speed. This range is from 3.33 to 500 cycles per second, but because of difficulty in separating very low frequencies, the full accuracy of the analyzer is not guaranteed below 5.5 cycles. Curves showing the relation between vibrational frequencies and engine speed are given for typical orders in Figure 1.

These curves are plots of the relationship $f = k \times s/60$ where f is the frequency in cycles per second at which the vibration occurs, s is the motor speed in revolutions per minute, and k is the order—one of those

TABLE I—THE AUTOMATIC FREQUENCY ANALYZER MEASURES THE AMPLITUDES OF THE TWENTY-THREE HARMONICS OF THE FUNDAMENTAL MOTOR SPEED LISTED

2/5	3/2	8/3	11/2
1/2	8/5	3/1	7/1
9/16	27/16	7/2	8/1
2/3	2/1	4/1	9/1
1/1	9/4	9/2	10/1
6/5	5/2	5/1	

listed in Table I. If excessive vibration is encountered, it is important to locate the source of the trouble so that the vibration may be reduced. The key to the source is not the actual frequency at which the vibration appears, but rather the order of the vibration k , because for the reasons already stated, knowledge of this factor narrows the possible source of the excitation. The value of k could be determined by measuring both the frequency at which the vibration occurs, f , and the engine speed, s , but this would require searching for vibrations at all frequencies within the band from 3.33 to 500 cycles. A more direct method is to search for vibration at some fixed order. In a given installation, there are only a limited number of these to be considered, and if excessive vibration is found at any one of them, the source of the trouble is at once indicated.

This new automatic analyzer, therefore, is arranged to plot a curve showing the relationship between the amplitude of vibration and the engine speed for one particular order at a time. Each test thus follows one such curve as those of Figure 1. The actual frequency of vibration, f , may readily be determined, if desired, from the equation. How the circuit works may be understood with the help of the block schematic shown in Figure 2. The nature of vibration at some point on the engine or airplane is indicated by the electrical output of a pickup device attached at that point. After the signal has passed through the circuit, the frequency component of one order is rectified and moves the pen of the recording instrument at right angles to the direction of motion of the chart by an amount proportional to its amplitude.

The engine speed is indicated by its proportionality to the output of an electric tachometer which is coupled to the engine. The output of this

tachometer is proportional in frequency and voltage amplitude to the engine speed, and after it is amplified and rectified it is allowed to control the motion of the chart of the recorder so that it takes a position that represents the engine speed. Each curve drawn on the chart thus gives the amplitude of vibration for one particular order of frequency, as the engine speed varies over its entire range.

Since the output of the pickup will include components at a number of different orders of frequency, it is necessary to provide some method of selecting some particular one, and of permitting only this component to control the pen of the recorder. This selection is accomplished by modulating the output of the pickup with the output of an oscillator whose frequency is controlled by the engine speed, by selecting one side band with a narrow-band filter, and then demodulating this single-frequency output with the same oscillator frequency.

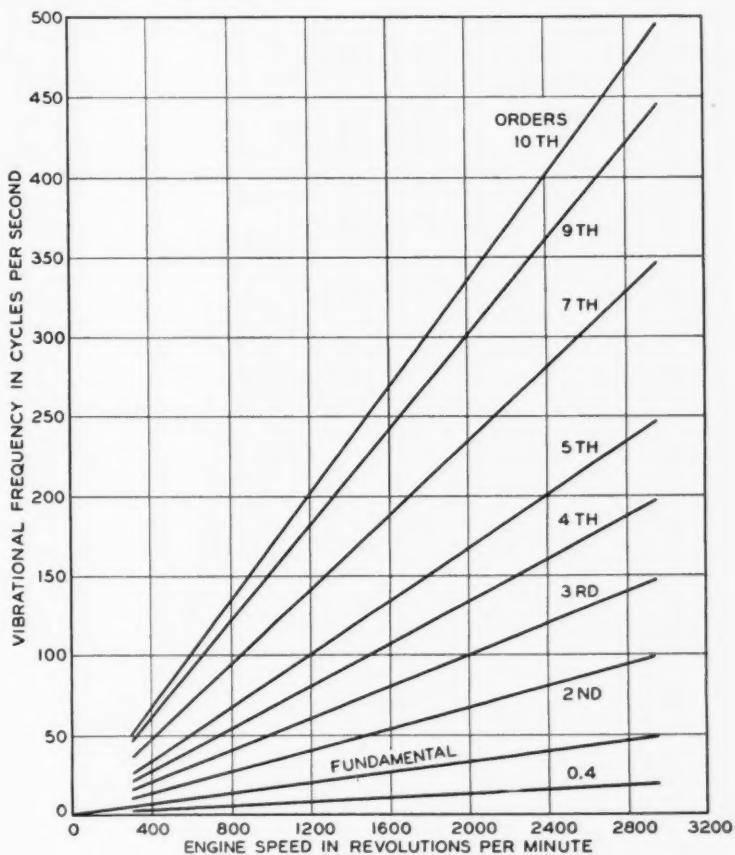


Fig. 1—Vibration frequency for various harmonics as engine speed changes from 500 to 3,000

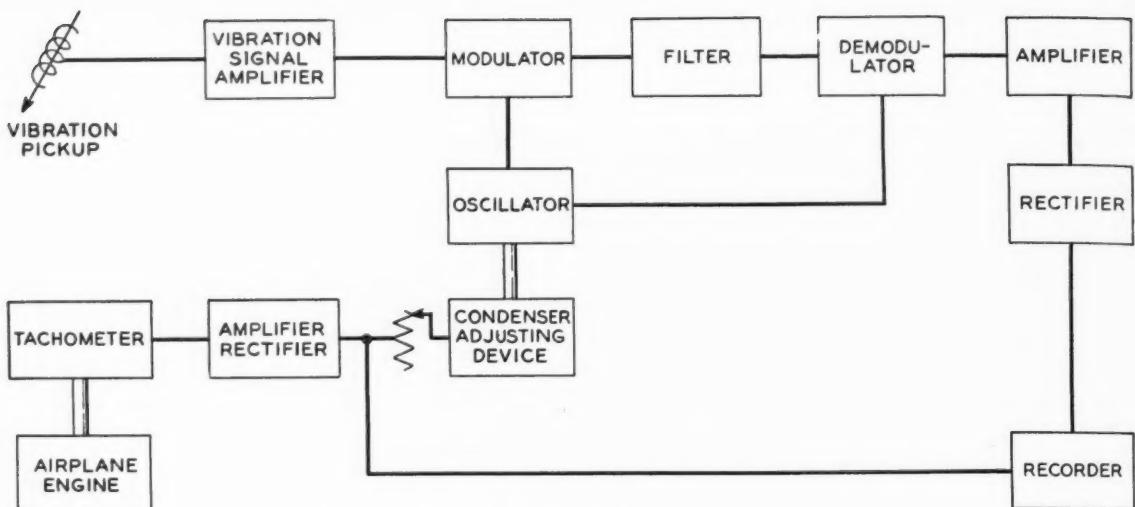


Fig. 2—Block schematic of analyzer circuit

The desired frequency component is one of the products of this latter modulation, and after amplification and rectification it is used to operate the pen of the recorder.

The modulating oscillator frequency is determined by a tuning condenser operated by a controlled electric motor. Besides driving the tuning condenser the motor also drives a rheostat in a bridge circuit, and for each setting of the condenser there is a corresponding setting of the rheostat. When the bridge circuit is in balance, no driving voltage is applied to the motor, but when the rheostat setting is one that does not balance the bridge, the motor will be driven in a direction to bring about balance. The setting of the rheostat at which the bridge is balanced is different for each applied voltage, and as a result of the action of the motor when the bridge is unbalanced,

both rheostat and tuning condensers tend to be held at a position that corresponds to the voltage applied to the bridge circuit. This voltage applied to the circuit is the rectified tachometer voltage placed across a potentiometer with twenty-eight fixed positions, and at each position the potentiometer applies to the bridge circuit a voltage proportional to the engine speed times the harmonic factor, and thus to the frequency of the k th harmonic of the motor speed.

The oscillator is designed to have a frequency of $(92,000 + f)$ where f depends on the setting of the tuning condenser. Since the condenser setting is made proportional to the voltage being measured by the bridge circuit, this frequency, f , is also proportional to it, and the design of the circuit is such that the proportionality factor is 1. The frequency to be measured is proportional to

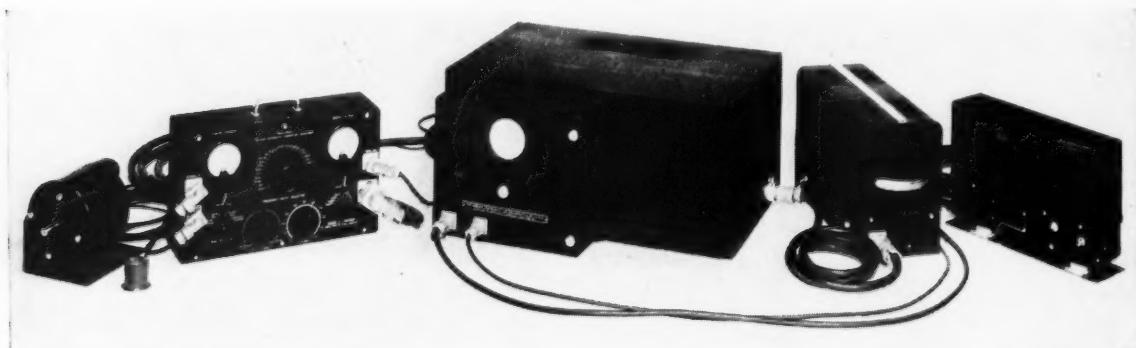


Fig. 3—The frequency analyzer includes a tachometer, a control unit, an analyzer unit, and two power units, besides the pickup device and the recorder

this voltage, and consequently f is equal to f , the frequency to be measured.

These two frequencies, f from the amplified output of the pickup and $(92,000+f)$ from the oscillator, are modulated together in a circuit arranged to balance out the oscillator frequency. The chief components in the output are thus the sum and difference frequencies, or $[(92,000+f)+f]$ and $[(92,000+f)-f]$. They are thus $(92,000+2f)$ and $92,000$.

The filter to which the output of the modulator is connected is of the crystal type, and has a pass band at $92,000$ cycles that is only 4 cycles wide. The $92,000$ -cycle side band is thus readily passed, while the other side band is rejected. This $92,000$ -cycle signal is now mixed in another vacuum-tube circuit with the output of the same oscillator, and the chief output components of this modulation are the oscillator frequency and the upper and lower side bands, or $[92,000+f]$, $[(92,000+f)+92,000]$, and $[(92,000+f)-92,000]$. Reduced to their simplest forms, these are $(92,000+f)$, $(184,000+f)$, and f . The high frequencies are easily re-

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From 1935 to 1940 he was with the Philco Radio and Television Corporation. In 1940 he joined Electrical Research Products where he engaged in the development of industrial measuring instruments and low-

frequency amplifiers for special applications. Transferring to the Commercial Products Development Department of the Laboratories in May, 1942, he engaged in completing the development of the wave analyzer. Since then he has been concerned with the development of equipment for the Armed Forces.

April 1944



Fig. 4—Only the control unit requires attention during a test

jected, and the frequency f is rectified and then passed to the recorder to control the position of the pen.

The equipment of the automatic frequency analyzer, Figure 3, consists of a small control cabinet accessible to the person making the test, a main analyzer unit with the tuning condenser drive device attached to the front of it, and a power supply unit. In addition, there is the tachometer and an amplifier and power supply for the driving unit of the tuning condenser. The recorder is not shown in the photograph. None of these latter units, nor the tuning condenser drive, is supplied by the Laboratories. The only unit requiring attention during a test flight is the control unit shown in greater detail in Figure 4. This unit includes two indicating meters, one to show the amplitude of the measured signal and one the motor speed. The operator thus has an indication of any abnormally large vibration and the engine speed at which it occurs without watching the recorder. The only control requiring attention during normal operation in flight is the frequency ratio selector, with which the order to be measured is selected.

In addition, there is an attenuator in the signal input to the analyzer to permit vibrations of very large amplitude to be kept within the range of the recorder and the indicating meter. There is also a potentiometer to give manual control of the har-



monic measured over a continuous range for a fixed motor speed instead of the step range provided by the frequency ratio selector switch. This potentiometer, which determines the voltage applied to the control device of the tuning condenser, receives its voltage supply from a calibrating oscillator

incorporated in the set, instead of from the tachometer.

Besides these, there are four controls used for calibrating the set. Two methods of calibration are provided, one a quick check to be used in flight and the other a more thorough calibration on the ground.

EXPERIMENTAL MICRO-WAVE SYSTEM PROJECTED

PLANS for the trial of a new type of intercity communications facility were announced on March 16 by the American Telephone and Telegraph Company. The work will take at least two years to complete and will cost more than \$2,000,000. It will supplement present commercial long distance telephone facilities and provide network facilities for the transmission of television programs between New York, Boston and intermediate points.

Application is being made to the Federal Communications Commission for approval to begin the project, which is expected to proceed as rapidly as the war situation permits. At present engineers of these Laboratories essential to technical phases of the undertaking are engaged in war work.

The new system will be operated by radio relays of a type which was under development by the Laboratories prior to the war. This system applies to communication by radio many of the techniques which have played an important part in the development of long distance wire telephone circuits. Directed radio beams at ultra-high frequencies will operate simultaneously in both directions and these will be relayed at stations spaced at an average of about thirty miles throughout the route. It is hoped that, ultimately, each radio beam will carry a large number of communications channels.

This is the first plan for a system of this type to handle regular commercial long distance telephone messages over land within the United States and it is believed that it will be the first to handle commercial communications services anywhere in the world.

This project represents another step in the march of radio telephony to utilize shorter and shorter wave lengths. Overseas

commercial radio telephony to England was initiated by the Bell System in 1927 using very long waves. Soon afterward "short waves" were developed for transocean telephony and today, except for the war, it is possible to talk from any telephone in the United States to more than seventy foreign countries and to any of more than 95 per cent of all the telephones in the world.

Using still shorter waves, only two or three meters long, which do not travel much beyond the horizon, radio telephone service was established just before the war across Chesapeake Bay between Norfolk and Cape Charles, across Massachusetts Bay between Boston and Provincetown, and between the mainland and Smith and Tangier Islands in Chesapeake Bay.

The new project proposes to use micro-waves which are shorter than have heretofore been used for commercial telephony.

The principal purpose of the trial is to determine by practical operation in commercial service the relative advantages and disadvantages of radio relay in transmission of long distance messages and television programs compared with transmission by the familiar wires and cables and recently developed coaxial cables. Relative costs represent only one of the factors to be determined, others include the relative quality of transmission, flexibility under actual operating conditions and dependability.

Post-war plans were recently announced for a country-wide extension by the Bell System, by about 7,000 miles, of its coaxial cables suitable for telephone service and the transmission of television programs. It is hoped that the new radio system will prove to be valuable as an additional means of meeting the nation's telephone and television communications requirements.